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FAILURE MODES, EFFECTS AND CRITICALITY ANALYSIS (FMECA) OF CATEGORY III INSTRUMENT LANDING SYSTEM

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16. Abstract

A Failure Modes, Effects and Criticality Analysis (FMECA) is used to optimize system performance by identification (and subsequent elimination) of all potentially hazardous failure modes affecting either personnel safety or operational mission success. The in-depth systematic approach of such an analysis provides the quantitative assurance that the system design has achieved the highest standards of system reliability and integrity.

The FMECA performed under contract number DOT-FA71WA-2635 for the FAA on the Texas Instruments Incorporated FAA Mark III ILS identified changes/modifications which were required in order for the system to comply with the quantitative requirements imposed upon the reliability of the system. These changes/modifications have been incorporated into the design and, as a result, the design meets and exceeds the required reliability criteria set for the system. Another major valuable output of the FMECA deals with performance assurance measures (preventive maintenance). All relevant hidden equipment failure modes are identified within the analysis and, based upon allowable probabilities of occurence, their respective preventive maintenance frequencies are specified.

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1.0 INTRODUCTION

The increase of aircraft transportation during the last ten years has been nothing less than phenomenal. To accommodate this increase greater demands must be imposed upon aircraft and their associated ground support equipments. Higher equipment reliabilities and extremely low probabilities of mission failure are natural requirements which must be fulfilled in this area with the aid of modern technologies.

An instrument landing system (ILS) is one such ground support equipment which embodies these requirements. The ILS, providing guidance to approaching or landing aircraft under adverse weather conditions, must employ "optimum" design and reliability to ensure personnel safety. This is especially true in the Category III ILS which provides guidance information from the coverage limit of the facility at which it is installed to, and along the surface of the runway. To ensure that the "optimum" in equipment performance is achieved, a qualitative system analysis which stratifies all possible modes of failure, their criticality and effect on mission success must be accomplished. Such an analysis, called a Failure Modes, Effects and Criticality Analysis (FMECA), has been performed by Texas Instruments Incorporated on its Category III ILS (FAA Mark III ILS) and is the subject of this report.

1.1 Safety Requirement

It is impossible to achieve the implementation of a system with infinite reliability and safety; therefore, it becomes necessary that some safety/reliability goal be established to enable the relative safety of the ILS to be determined. For Category III operations, there is a brief time period during which the safety of the aircraft becomes completely dependent upon the integrity of the electronic system. Failure of certain critical ground based components during this time period could possibly result in a catastrophic event. In an attempt to quantify the safety of the equipment, the figure specified is a probability of 1 failure in ten million landings. This figure was derived by the British Air Registration Board from human mortality data and safety records of aircraft. This requirement indicates that the landing operation under Category III conditions would be safer than a person can predictably expect to be in his normal day-to-day activities. The value, if anything, is on the stringent side, in that it is not possible to categorically state that a given failure will be catastrophic, but only that it will produce a potentially hazardous situation that may be catastrophic if the proper corrective action on the part of the aircraft crew is not taken.

The relationship of mean-time-between-failures (MTBF) to the overall system reliability requirement is as follows:

The predicted localizer hardware MTBF is approximately 1200 hours and that of the glide slope is 1800 hours. Any given failure in the equipment will contribute to a lower MTBF but will not necessarily interrupt the operation or even degrade the operational category status (Category III or II). This is possible through appropriate equipment redundancy so that when individual component failures occur, continued operation may still be possible. Consequently, it is possible for the probability of operational failure to be far less than a component failure. Given that the ground system is fully operational at the inception of a Category III ILS approach, the probability of malfunction of the radiated signal (both localizer or glide slope) during the critical part of the approach (defined as ten seconds for the localizer and five seconds for the glide slope) should be less than one in ten million which corresponds to an equivalent MTBF of operation in the order of 27,000 hours.

2.0 PURPOSE

The primary purpose of performing an FMECA upon the Category III ILS is to insure that the equipment design is such that the probability of a potentially hazardous failure (loss of signal or radiation of an erroneous signal) during the critical phase of Category III landing is less than 1×10^{-7}. In addition, a number of secondary objectives exist: (1) to reveal hazardous failure modes jeopardizing personnel safety and/or system performance status; (2) to enumerate all relevant functional failure modes along with their effect and failure rate; (3) to serve as a documented aid in the troubleshooting process of field failures in the future; (4) to serve as an objective evaluation of both the equipment specification and its design; and (5) to determine the frequency of preventive maintenance in checking for hidden failures.

3.0 SYSTEM DESCRIPTION

A Category III ILS provides aircraft with guidance information from the coverage limit of the facility to, and along, the surface of the runway. The system under analysis has operational performance of Category III, that is, operation with no decision height limitation. Initially the system will be used in Category IIIA operations in which the pilot will make use of external visual references during the final phase of landing and with a runway visual range (RVR) of not less than 700 feet. The ILS must be suitable for eventual use by automatic control system for roll-out, which will be used in Category IIIB operations with runway visual ranges down to 150 feet.

The ILS system basically consists of two separate stations - the localizer and the glideslope, depicted in simplified block diagram form by figures 3-1 and 3-2 respectively. In addition to these stations, a central point for station control and the display of station status exists at the control tower. Up to three marker beacons are also utilized in a typical ILS installation. However, no description of the marker beacons will be provided since they will not be considered in this analysis.

3.1 General Descriptions

The localizer provides guidance in the horizontal plane to aircraft engaging in approaches to, and landing at, airfields. The localizer antenna group radiates two VHF carriers, each amplitude modulated by 90 and 150 Hz and both carrier frequencies within a particular VHF channel. The radiation field pattern produces a course sector with one tone predominating on one side of the course line (runway center line) and with the other tone predominating on the opposite side. Along the course line, the 90Hz and 150Hz modulations have the same levels. Being a two-frequency, capture effect system, one of the carriers (course) provides a radiation field pattern coverage in the front course sector; the other carrier (clearance) provides a radiation field pattern coverage outside that sector to ±60 degrees from the course line.

The glideslope station provides guidance in the vertical plane. It produces a UHF composite field radiation pattern which is amplitude modulated by 90 and 150 Hz. The pattern provides a straight line descent path in the vertical plane containing the runway center line, with the 150 Hz tone predominating below the path angle and the 90 Hz tone predominating above the path angle. In addition to this course coverage, a clearance UHF carrier is modulated by 150 Hz to provide low angle coverage. Both carriers (course and clearance) are within a particular glideslope UHF channel.

3.2 Localizer

Referring to figure 3-1, there are two transmitter sections incorporated into the localizer station. One transmitter is designated as the main transmitter and the other, the standby transmitter. Automatic changeover capabilities are provided. While the main transmitter radiates into the antenna system, the standby transmitter will be operating into dummy loads. Whenever the main transmitter shuts down due to some equipment failure, the standby transmitter is transferred immediately to the antenna system.

A brief explanation of each transmitting unit is in order. The course transmitter delivers a VHF carrier (108-112MHz) frequency to the solid state modulator where it is modulated by 90 and 150 Hz tones. Two signals (figure 3-2) are generated by the modulator: carrier plus sidebands (C+SB) and sidebands only (SBO). The modulator also delivers to the clearance transmitter a composite of low frequency 90 and 150 Hz tones to modulate the clearance carrier, generating the clearance C+SB. In addition, low frequency 90 and 150 Hz tones and clearance carrier are supplied to the sideband generator where the clearance SBO is generated. The identification unit, which provides the pilot identification of the runway and the approach direction, generates a 1020 Hz identification signal which modulates both the course and clearance carriers.

The output signals from the main and standby transmitting units are routed to the changeover and test unit where transmitter transfer capabilities are accomplished. Signals received from the control unit determine which transmitter operates into the antennas - main or standby. When the main transmitter is connected to the antenna system, the standby transmitter operates into dummy loads. When the standby unit is connected to the antenna system, the main unit is turned off. Within the changeover and test unit there exists circuitry for use in monitoring standby transmitter parameters.

From the changeover and test unit, the course and clearance transmitter signals (C+SB and SBO) are fed to the course and clearance distribution circuits respectively. Each of the distribution circuits merely distributes the C+SB and SBO signals to the localizer antennas. Phasing relationships and signal combinations are accomplished within the distribution circuits so that the proper field radiation pattern is established via the antennas. The antenna assembly consists of a parabolic reflector with directional exciters and a clearance array. The parabolic reflector with directional exciters (three directional antennas) is used in es-

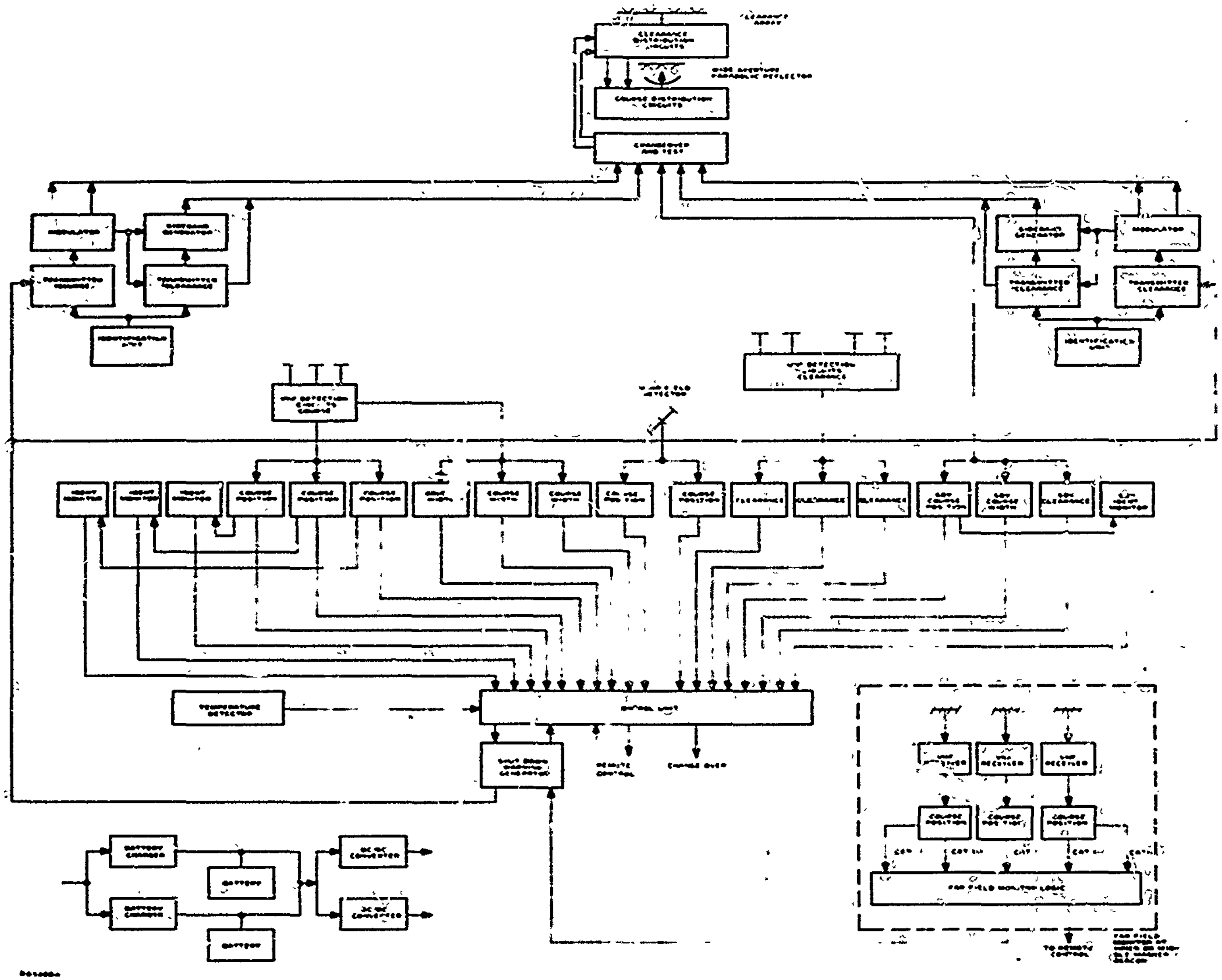

Figure 3-1. Category III Two-Frequency Localizer Wide Aperture Configuration Block Diagram

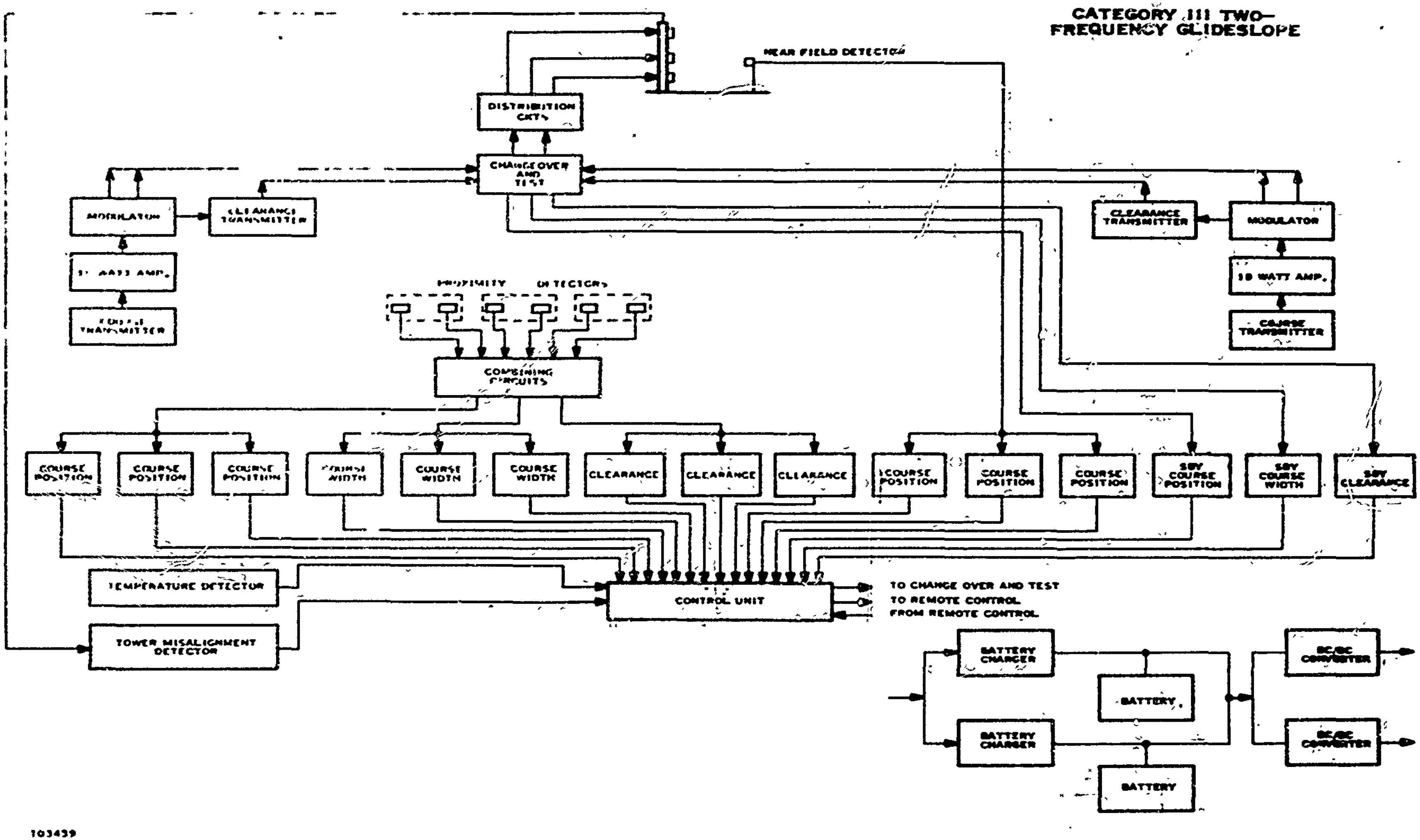

Figure 3-2. Category III Two-Frequency Glide Slope Block Diagram

tablishing the course field radiation pattern; however, to establish the clearance field radiation pattern both the clearance array (consisting of 4 antenna elements) and the course antenna system are required.

To provide integral monitoring ability of the radiated signal parameters, proximity detectors are utilized. Each transmitting source is sampled by a proximity probe. The captured signals are then combined (in the distribution circuit cabinets) to provide the proper signals with which system parameters are monitored. The system parameters which are monitored are: course position, displacement sensitivity, carrier power level, percentage modulation, identification signal, and clearance monitoring.

Triplicate monitoring of each of these parameters is incorporated as shown in figure 3-1. When the tolerance limit of any parameter is exceeded, an alarm signal from each of the respective monitor channels is fed to the control unit, from which a transfer to the standby transmitting unit is initiated. The control unit acts upon a 2 of 3 vote to initiate the transfer.

In addition to the integral monitoring of system parameters, near field and far field course position monitoring is also incorporated. The near field monitoring utilizes a single yagi antenna to provide dual monitoring ability. The far field monitoring utilizes three Yagi antennas feeding triplicate VHF receivers and triplicate monitor channels with a 2 of 3 vote. Both near field and far field alarm signals are delayed to prevent disturbances created by aircraft overflights and landings from causing equipment alarm and shutdown.

The same system parameters are monitored for the standby transmitting unit as for the main transmitting unit. However, only single monitoring is incorporated. Upon an alarm from any standby monitor, the standby transmitting unit will be shut down after a nominal 5 second time delay.

The far field monitor has its own alarm processing circuitry to minimize the quantity of telephone lines needed for remote transmission. Each far field monitor channel provides two alarm outputs - a Category III alarm and a Category II alarm. The difference between these two alarm outputs is merely in tolerance limits. A two of three vote is utilized for both the Category II and Category III alarms. Time delays are associated with the final alarm outputs for both categories; however, the Category III alarm time delay is accomplished at the remote control unit in the control tower (the Category III alarm signal is conveyed directly to the tower where performance downgrade is accomplished). Besides a general power/temperature alarm and a

far field monitor bypass signal, three signals are sent to the localizer control unit - a monitor mismatch, a shutdown alert, and a shutdown. A monitor mismatch signal indicates that one of the three Category II monitor channel alarms has existed over a definite time period (nominal 120 seconds). A shutdown signal indicates that 2 of 3 Category II monitor channel alarms have existed over a set time period (nominal 70 seconds). When received at the localizer control unit, this shutdown signal will immediately shut down the entire localizer station. The shutdown alert signal precedes the shutdown signal by a nominal 5 seconds. The shutdown alert signal initiates a shutdown warning signal (within the control unit) which is transmitted to the pilot to give him an advance warning of the forthcoming shutdown.

The localizer control unit processes alarm signals received from the monitor channels. If only one alarm is received from any monitor channel set, a MONITOR MISMATCH lamp located on the control unit front panel will illuminate. All integral monitor alarms require a two of three voting to initiate a transfer command. An actual transfer will be accomplished only if the standby transmitting unit is available while the main is operative. If either the standby transmitter is operative (on the air) or if it is shut down, a transfer command leads to a localizer shutdown. If both near field monitors alarm, a direct localizer shutdown will result after the nominal 5 second time delay. A shutdown alert is also initiated prior to the shutdown command of the near field alarms.

In addition to the alarm processing already described, the control unit:

1. Provides signals to the remote control unit showing the status of the main and standby transmitting equipment.
2. Provides signals to the remote control unit downgrading the facility performance Category III status to Category II if the standby equipment is either not available or is on the air.
3. Processes transmitter "cycle" commands received from the remote control unit.
4. Visually displays all alarm conditions and transmitter status.
5. Provides for the selection of the main transmitting unit.
6. Provides for the bypassing of all monitor channels.
7. Provides for the memorization or non-memorization of monitor alarms.

8. Provides for the selection of command control from either the remote control unit or the localizer control unit.

9. Inhibits restoration of radiation for at least 20 seconds after localizer radiation has been shut down.

10. Provides for testing the integrity of both abnormal indication and monitor alarm lamps with a bulb test switch.

11. Provides signals to the remote control unit showing either (1) monitor alarm abnormals or (2) power/environmental abnormals. (Note: power/environmental abnormals downgrade system performance status from Category III to Category II after a preset time delay.)

With regards to system power supplies, redundancy is highly incorporated. The two main battery chargers are connected in parallel, each possessing the capability of independently supplying the load current and voltage. Each battery charger has its own respective battery which it keeps fully charged. Two DC/DC converters, receiving their input from the common charger output voltage (+28 volts), produce the remaining system dc voltages. Each converter voltage is virtually in parallel with the other respective converter voltage, thus providing a dual redundancy of all system dc supply voltages.

3.3 Glideslope

The simplified block diagram of the glideslope station is presented in figure 3-1. As is evident the configuration of the station is very similar to that of the localizer. Some of the major differences are: (1) the glideslope does not possess either a far field monitor or an identification unit/monitors (2) the glideslope has an antenna tower misalignment detector (3) triplicate near field monitors are utilized for the glideslope (4) no shutdown alert warning signal is provided.

The transmitter section is also slightly different. The course transmitter delivers a UHF carrier (328.6 - 335.4 MHz) frequency which is amplified by the 10 watt amplifier. This amplified carrier is then delivered to the solid state modulator where, as for the localizer, it is modulated by 90 and 150 Hz tones. The two signals, C+SB and SBO are generated by the modulator. In addition the modulator also provides a low frequency 150Hz signal used for modulating the clearance carrier within the clearance transmitter. The clearance signal is only C+SB 150 Hz.

The changeover and test unit provides the same function as that of the localizer - transfer transmitter signals of the main and standby unit either into the antenna system (including distribution circuits) or into dummy loads. Also within the changeover and test unit there exists circuitry for monitoring of the standby transmitter parameters.

From the changeover and test unit, the three signals (course C+SB, course SBO, and clearance C+SB 150) are routed to the distribution circuits where these signals are combined and distributed to the three 2-lambda glideslope antennas. Correct phase relationships are established within the distribution circuits. The three 2-lambda antennas (M-array) are identical and are mounted on the tower at 3 different heights (H, 2H, 3H). H is dependent both upon the radiating frequency and the glide path angle.

Proximity field detectors are employed to provide integral monitoring ability of the radiated signal parameters. The UHF combining circuits combine the signals provided by the probes so that parameter monitoring can be accomplished. The parameters to be monitored are: path alignment (course position), carrier power level, percentage modulation, path width (displacement sensitivity) and the clearance signal. As in the localizer, triplicate monitoring of all parameters is incorporated.

In addition to integral monitoring, near field monitors are provided to monitor the path angle (course position). The near field monitor antenna couples the appropriate signal to three parallel monitor channels. A two of three vote for monitor channel alarms is utilized. Since aircraft overflights may cause field disturbances which will create near field alarms, the alarms are delayed a nominal 2 seconds at the control unit. "True" near field alarms lead directly to station shutdown.

As in the case of the localizer, the same standby parameters are monitored for the standby transmitting unit as for the main transmitting unit. Again, only single parameter monitoring is incorporated.

A glide slope antenna tower deformation monitor is employed to verify the integrity of the tower. If misalignment or deformation of the antenna tower persists for a nominal 135 seconds, an alarm is provided to the control unit which will shut down the entire glideslope station. The misalignment detector is mounted at the top of the antenna tower and is nominally set to detect a five inch deflection at the top of the tower.

The glideslope control unit utilizes the same printed wiring boards as the localizer. (Actually there is one less board used in the

glideslope). Hence all functional operations and displays of status are identical. For minor differences (such as a misalignment detector alarm versus the far field monitor alarms) strap options are employed.

3.4 Remote Control Unit

The remote control unit, figure 3-3, receives inputs from the localizer station, the glideslope station, and each of the marker beacons. It is used for the display of all status information from these stations. It also provides for remote cycling capability of transmitting units for each station (cycle sequence: MAIN-OFF-STANBY-OFF).

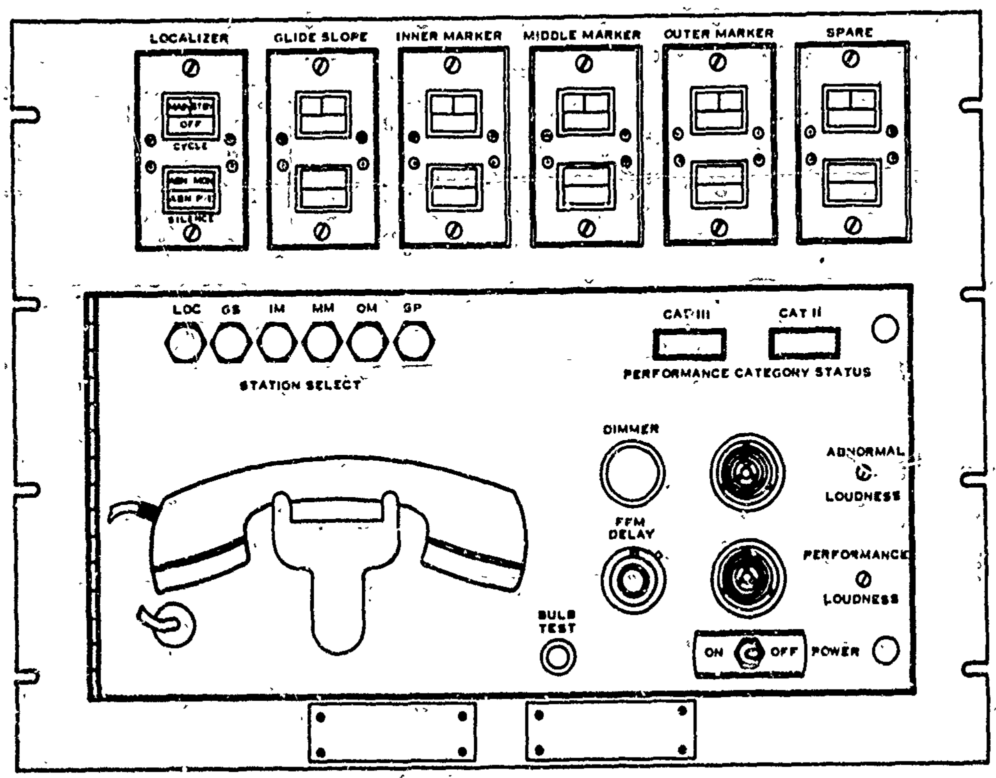

Figure 3-3. Remote Control Unit

Two ABNORMAL indications are provided for each station - MONITOR ABNORMAL and POWER/ENVIRONMENTAL ABNORMAL. The MONITOR ABNORMAL lamp is illuminated whenever:

- The main transmitter is not operational.
- A mismatch exists on one of the monitor channel sets (i.e. one monitor channel out of three is in alarm).
- A main inhibit is generated (note: a main inhibit inhibits the main monitor channels).

- An alarm has occurred on the standby monitor channels (the alarm may be due to either a failure in the standby transmitter or in one of the standby monitor channels).
- For the localizer, a far field shutdown alarm has occurred; for the glideslope, a misalignment detector alarm has occurred.
- The monitors locally bypassed (MLB) mode of operation is selected. (Note that under this condition the ABNORMAL lamp will be flashing).

The POWER/ENVIRONMENTAL ABNORMAL is illuminated whenever:

- One of the DC/DC converter voltages fails.
- The temperature limits are exceeded.
- The primary power to either of the two battery chargers fails.
- Either of the battery chargers fail.
- The terminal battery voltages drop below a preset level.
- For the localizer, a power/temperature alarm occurs at the far field monitor.

When either of these abnormals are generated an audible alarm is sounded. By depressing the SILENCE switch, the audible alarm is turned off.

An ILS performance category status is also provided for visual display at the remote control unit. The Category III lamp is illuminated only if all of the conditions listed below are satisfied.

1. Localizer main transmitter is on the air.
2. Localizer standby transmitter is available.
3. Localizer far field course monitors see the course position parameter within Category III tolerance limits (adjustable 20 second time delay available).
4. Localizer monitor channel inhibit is not present.
5. Localizer terminal battery voltage is above a preset level.
6. Glideslope main transmitter is on the air.
7. Glideslope standby transmitter is available.
8. Glideslope monitor channel inhibit is not present.

9. Glideslope terminal battery voltage is above preset level.

10. Outer marker beacon is on with no rf level or identification alarm.

11. Middle marker beacon is on with no rf level or identification alarm.

12. Inner marker beacon is on with no rf level or identification alarm.

13. Distance measuring equipment (DME) is within tolerance (if applicable).

14. The "absence" of localizer POWER/ENVIRONMENTAL ABNORMAL condition. (A time delay of up to 3 hours is used for this condition).

15. The absence of glideslope POWER/ENVIRONMENTAL ABNORMAL condition. (A time delay of up to 3 hours is used for this condition).

The Category II lamp is illuminated only if all of the conditions listed below are satisfied.

1. Either the localizer main or standby transmitter is on the air, provided that no monitor channel inhibit exists.

2. Either the glideslope main or standby transmitter is on the air, provided that no monitor channel inhibit exists.

3. The Category III indicator lamp is off.

4. Outer marker beacon is on with no rf level or identification alarm.

5. Middle marker beacon is on with no rf level or identification alarm.

6. Inner marker beacon is on with no rf level or identification alarm.

Whenever a change in performance category occurs, a momentary buzzer is triggered.

4.0 PROCEDURE

The following steps briefly summarize the general approach taken in this analysis:

1. The functional block diagram of the system is drawn, exhibiting all relevant signal flow paths between the various functional assemblies. In addition to the system block diagram, detailed functional descriptions (such as Boolean algebraic expressions and simplified assembly block diagrams) are provided when signal flow characterization is not readily attained at the system block diagram level.

2. Each functional entity in the system block diagram is then analyzed for all possible failure modes which have a direct effect on the system operational status. It should be noted that each failure mode listed reflects actual piecepart failure effects at the functional block output. The various failure mode effects and system failure indications are then tabulated.

3. Upon completion of the tabulation of the failure modes and effects, the failure rate of each failure mode will be calculated. That failure rate is the total failure rate of all the piecepart components which, upon failure, produce that functional failure mode.

4. The final step of the FMECA is the verification that system design and reliability such that the probability of a potentially hazardous failure during the critical landing phase of a Category III landing is less than 1×10^{-7}. This is accomplished by developing mathematical models which entail all conceivable events (or sequence of events) that lead to one of two probabilities of system failure: (1) the loss of signal (station shutdown) or (2) the radiation of a hazardous signal (out of Category III tolerance). The probability math models for each of these conditions are determined by utilizing the failure modes and effects data. The final calculation of the probability of the Category III SSILS mission failure is then performed.

5.0 ASSUMPTIONS/CONSIDERATIONS

The FMECA was not performed at piecepart level but rather at the functional level, i.e., the level at which one or more distinct circuits serve a separate system operational function. In most cases this functional level neatly coincides with the assembly level of the system. To perform a piecepart analysis on a system as extensive as the SSILS was judged neither necessary nor desirable.

Prior to any failure both the localizer and glideslope are operating on main transmitting units in Category III performance status as indicated by the remote control unit CAT III status indicator. On a per station basis, Category III performance status simply implies that (1) the main transmitter is on the air, operating within Category III tolerance limits; (2) the standby transmitter is available (3) a power or environmental alarm has not existed over some preset interval of time (3 hours maximum). For descriptive purposes within this analysis, transmitting unit number 1 will be considered as main and transmitting unit number 2 as standby.

When the monitoring system of the SSILS is functioning properly (no monitor malfunctions present), radiation pattern degradations beyond the Category III tolerance limits are detected. Hence, the criteria for establishing a "true functional (or catastrophic) failure" is that it degrades the radiated signal beyond the alarm limits of the monitors.

Only single piecepart failures (open/short component failures) are considered in the determination of functional failure modes. However, multiple functional failure modes will be considered for the determination of hazardous failure conditions.

The following are excluded from the analysis:

a. Monitor indicator circuitry not affecting operational status (such as alarm memory latches, lamp drivers, bulbs, metering circuitry).

b. Intercom circuitry - not vital for system operation.

c. Marker beacons - not vital for Category III operation.

d. Heater resistors within the cabinets of the distribution circuits. Since distribution circuitry failures are considered in the analysis, the cause of failure, temperature or otherwise, is immaterial to this analysis.

The analysis of the remote control/status display is given in paragraph 10. With regards to this analysis, it will be assumed

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that the operator will check the transmitter status of each station and determine that the CAT III status indicator lamp is lit prior to a Category III landing.

The following failure modes are considered not hazardous:

a. Loss or degradation of the identification signal.

b. Loss or degradation of the shutdown alert signal.

c. Generation of an erroneous shutdown alert signal.

d. Loss of Category II near field monitoring ability.

e. Generation of erroneous power/temperature alarms.

The critical landing phase period for the localizer is 10 seconds; for the glideslope 5 seconds.

The probability of failure P(F) is equal to λt.

Note: The probability of success is given by the expression

$$P(S) = e^{-\lambda t}$$

Utilizing the exponential expansion,

$$P(S) = e^{-\lambda t} = 1 - \lambda t + \frac{(\lambda t)^2}{2} - \frac{(\lambda t)^3}{6} + \dots\dots\dots\dots$$

For values of $\lambda t << 1$,

$$P(S) = 1 - \lambda t$$

Therefore the probability of failure is:

$$P(F) = 1 - P(S) = 1 - (1 - \lambda t) = \lambda t$$

External runway disturbances such as aircraft overflights and runway activity have an adverse effect on the radiated localizer signal at the far field. The parameter of interest at the far field is the difference in depth of modulation (DDM). This parameter is affected by such disturbances and, hence, is monitored at the far field. The loss of this monitoring can lead to potentially hazardous conditions. An obstruction could exist between the localizer antenna and the far field monitor which would not be detected by the integral monitors or the near field monitors. Hence, to accomplish the primary purpose of the FMECA, the probability of external runway disturbances during the critical landing phase of a Category III landing must be known. However, the calculation of this probability requires a statistical analysis utilizing empirical data. Since such data is presently unavailable, a maximum allowable probability of occurance is established within the analysis of the FMECA and is listed as an assumption. The assumed value of this probability is 1×10^{-3}.

The proper alignment of the glideslope antenna tower is vital for the radiation of correct signals. The alignment is monitored for permanent deformations due to such natural forces as earth tremors, strong winds, tower settling, etc. This probability of permanent misalignment (within the preventive maintenance cycle of a one week period) must be known for the accomplishment of the FMECA. Since such a probability is unavailable for this analysis, a maximum allowable value is again assumed. A maximum number for this occurrence is 1×10^{-5}.

Coaxial cables, connectors, antennas and probes will not be treated independently for failure modes and effects, but rather are considered in the analysis as part of the functional block to which they are associated since the analysis is performed at the functional level.

The assignment of a criticality number to each failure mode is the conventional means of performing a criticality analysis. Such an approach, however, tends to be partially subjective due to weighing factors by which the criticality number is established. A more objective approach is: (1) to provide merely the failure rate as a representation of the criticality of each failure mode; and (2) to identify each failure mode as being either hazardous or not hazardous. These two items, moreover, are necessary inputs toward accomplishing the primary purpose of the FMECA as outlined in the procedure. For these reasons this approach will be utilized for the criticality analysis of the FMECA.

The failure rates used in this analysis were derived using the following considerations:

a. Source of base failure rates was RADC Reliability Notebook, Volume II, dated September 1967. (RADC-TR-67-108)

b. Equipment ambient temperatures was 25° C. Appropriate temperature rises were used for the part ambients depending upon their location in the equipment.

c. Environmental factor was "ground fixed" as defined in the RADC notebook.

6.0 FUNCTIONAL BLOCK DIAGRAMS

Appendices A and B contain detailed functional block diagrams of the localizer and glideslope respectively. It is at that functional level the FMECA will be performed. Also contained in the appendices are all the functional block diagrams of each major assembly. All the various functional block diagrams may be utilized to obtain a rather detailed understanding of system operation.

Two observations should be made concerning the general station block diagrams. First, all signals which can affect station operational performance are provided in the diagrams. Hence, only the outputs from each functional block need to be considered for analysis. Secondly, each functional block has an identification number by which the results of the tabulated analysis may be brought into system perspective. Additional clarification of the tabulated results of the FMECA can be attained when the functional block is viewed at the system level.

The detailed diagrams of the control unit for each station should be particularly useful for a thorough understanding of control unit operation. The Boolean expressions provided completely characterize all major logic signals and commands. Hence, these diagrams should be a tremendous aid in troubleshooting control unit failures.

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7.0 FAILURE ANALYSIS

The heart of the FMECA is the failure analysis. This analysis identifies each failure mode, describes the corresponding failure effects, and lists the failure rate by which its criticality is measured. This failure analysis is performed in the form given in figure 7-1. The following clarification of terms should be made concerning this form.

1. Failure Mode: This is the item (functional block) failure mode. Each failure mode reflects the piecepart failures within the block that can affect the output signals in the prescribed failure mode. Such terms as "loss of signal" are normally applied to any failure condition that totally destroys the characteristics of a "good" signal. Also any radiated signal that is not degraded beyond the Category III alarm limits is not considered to constitute a functional failure.

2. Failure Effect: Normally listed under this term are the immediate failure effects upon the system (or station) from an operational standpoint. Effects on radiated signals may also be listed here. Occasionally incorporated within this column are some conditional failure effect comments - the effects upon the system operation if another failure were to occur.

3. System Operation After Failure: The system performance category immediately after the failure is revealed in these columns. These indications correspond to the performance indicator lamps at the Remote Control Tower. An "OFF" condition exists if the system is neither in Category II or Category III performance.

4. Failure Indications: The abnormal indication lights which should be lighted at the different locations after the failure occurs are presented in these columns. The Remote Control column lists the abnormal indications present at the Remote Control Tower. The Control Unit column is normally used to give the abnormal indications that are displayed on the respective station control unit front panel. The "other" column is normally utilized for any other display of abnormal indications such as the monitor channel alarm lights or the remote far field monitor indications. True monitor channel alarm light indications are revealed only in the monitors locally bypassed (MLB) mode of operation; hence, the monitor alarm light indications presented here are those that will be displayed in the MLB mode of operation. It should be

SYSTEM ____________

SUBSYSTEM ____________

PAGE ___ OF ___

IDENTIFICATION		FUNCTION	FAILURE MODE	FAILURE EFFECT	SYSTEM OPERATION AFTER FAILURE			FAILURE INDICATIONS			FAILURE RATE ($\lambda \times 10^{-6}$)	REMARKS
ITEM NAME	I.D. NO.				CAT III	CAT II	OFF	REMOTE CONTROL	CONTROL UNIT	OTHER		

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Figure 7-1. Failure Analysis Form

realized that the MLB mode is utilized during any failure troubleshooting.

5. Failure Rate: This column lists the total failure rate of the piecepart failures that can produce the respective functional failure mode. The failure rate given in this column is worst case since all component failure rates that can cause the particular failure mode are included regardless of the piecepart failure modes. In essence this number is a representation of the criticality of each failure mode - the larger the failure rate the greater the criticality of the failure mode. The failure rate number given in this column is in terms of failures per million hours. Failure rate identification is accomplished by alpha-numeric subscripts of λ. The numeric portion of the subscript applies to the identification of the functional block; the alphabetic portion identifies the specific failure mode. For example, λ1B implies the failure rate of the second (B) failure mode of the control unit (01).

The results of the failure analysis are provided in appendices C and D for localizer and glideslope respectively. The failure rates were determined on separate work sheets which will not be provided within this report. Table 7-1 provides an example of these work sheets, showing the failure rate calculations for two failure modes of the localizer control unit. All failure modes listed in the analysis are considered to be hazardous unless specifically identified to be "not hazardous" in the "remarks" column.

Table 7-1. Failure Mode Failure Rate Calculations

System SSILS

Subsystem LOCALIZER STATION

Identification		Failure Mode	Assy/PWB	Part/ Component	Failure Rate ($\lambda_i \times 10^6$)	Failure Rate ($\lambda_m \times 10^6$)
Item Name	I. D. No.					
Control Unit	01	Generation of an erroneous transfer signal, due to alarm processing circuitry.	Alarm PWB	U2 537051-1	+0.140	1.827
				U4 537051-1	+0.140	
				U6 537051-1	+0.140	
				U8 537051-1	+0.140	
				U13 537051-1	+0.140	
				U11 537051-1	+0.140	
				U16 537051-1	+0.140	
				CR2 JANTXIN 4148	+0.041	
				CR4 JANTXIN 4148	+0.041	
				CR6 JANTXIN 4148	+0.041	
				CR8 JANTXIN 4148	+0.041	
				Subtotal	+1.144	
			Alarm and time delay PWB.	U12 537051-1	+0.140	
				U4 537051-1	+0.140	
				U6 537051-1	+0.140	
				U8 537051-1	+0.140	
				CR 9 JANTXIN 4148	+0.041	
				CR11 JANTXIN 4148	+0.041	
				CR13 JANTXIN 4148	+0.041	
				Subtotal	+0.683	

Example

Table 7-1. Failure Mode Failure Rate Calculations (Continued)

System SSILS
Subsystem LOCALIZER STATION

Identification		Failure Mode	Assy/PWB	Part/ Component	Failure Rate ($\lambda_i \times 10^6$)	Failure Rate ($\lambda_m \times 10^6$)
Item Name	I.D. No.					
Control Unit (Continued)	01	Generation of an erroneous shut-down signal due to alarm processing circuitry.	Alarm and time delay PWB.	U2 537051-1	+0.140	3.507
				U13 537051-1	+0.140	
				R25 2K	+0.006	
				B26 4.7K	+0.006	
				R27 .0K	+0.006	
				R28 4.7K	+0.006	
				R29 2K	+0.006	
				Q9 JANTX2N2907	+0.102	
				Q10 JANTX2N2222A	+0.058	
				CR3 JANTXIN 4148	+0.041	
				CR4 JANTXIN 4148	+0.041	
				R32 10K	+0.006	
				R33 12K	+0.006	
				R35 4.7K	+0.006	
				R36 10K	+0.006	
				Q11 JANTX2N 4858	+0.475	
				Q12 JANTX2N 2222A	+0.058	
				Subtotal	+1.109	
			Far field/ shutdown alert PWB.	6.8K	+0.006	
				680Ω	+0.006	
				22µf	+0.038	
				JANTX2N 2222A	+0.058	
				10K	+0.006	
				537051-1	+0.140	
				Subtotal	+0.254	

Example

Table 7-1. Failure Mode Failure Rate Calculations (Continued)

System SSILS
Subsystem LOCALIZER STATION

Identification		Failure Mode	Assy/PWB	Part/ Component	Failure Rate ($\lambda_i \times 10^6$)	Failure Rate ($\lambda_m \times 10^6$)
Item Name	I. D. No.					
Control Unit (Continued)	01	Generation of an erroneous shut-down signal due to alarm processing circuitry. (Continued)	Pwr/envir. PWB.	U5 537051-1	+0.140	
				U3 537051-1	+0.140	
				Subtotal	+0.280	
			Alarm PWB	U11 537051-1	+0.140	
				U16 537051-1	+0.140	
				U15 537051-1	+0.140	
				U17 537051-1	+0.140	
				Subtotal	+0.560	
			Control/inhibition PWB.	U8 537051-1	+0.140	
				U5 537051-1	+0.140	
				R6 1K	+0.006	
				U12 537051-1	+0.140	
				U13 537051-1	+0.140	
				U2 537051-1	+0.140	
				U1 537050-1	+0.140	
				U4 537051-1	+0.140	
				R7 10K	+0.006	
				R5 10K	+0.006	
				Q1 JANTX2N 2222A	+0.058	
				R39 1K	+0.006	
				Q11 JANTX2N 2222A	+0.058	
				U11 537051-1	+0.140	
				C11 22µf	+0.038	
				R38 4.7K	+0.006	
				Subtotal	+1.304	

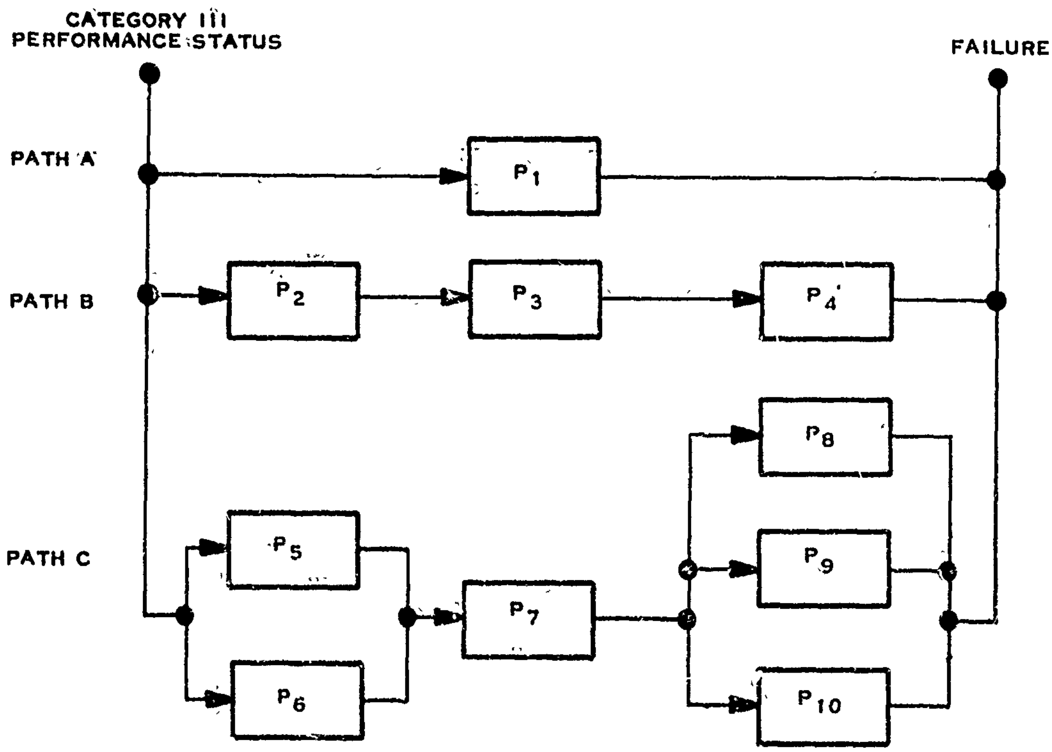
Example

8.0 MATH MODELS

To fulfill the primary objective of this analysis, it must be verified that the probability of a potentially hazardous failure (a loss of signal or the radiation of a hazardous signal) during the critical landing phase be less than 1×10^{-7}. To achieve this verification, probability math models are utilized.

Figure 8-1 provides an illustration of a typical probability math model. As can be seen, three distinct paths lead to a failure. If the event whose probability is given by P_1 occurs, a failure will result. For a failure to result due to path B events, all three events must occur, the probability of which is given by $(P_2 \cdot P_3 \cdot P_4)$. Path C is slightly more complicated. Either event 5 or event 6 must occur, event 7 must occur, and either event 8, 9, or 10 must occur to lead to a failure. Its probability of occurrance is given by $[(P_5 + P_6) \cdot P_7 \cdot (P_8 + P_9 + P_{10})]$. The overall total probability of a failure (P(F)) due to all three paths is simply the algebraic sum.

Rather than provide a graphical representation of the probability math models on the ILS system, it is decided to present only the probability equations of the math models. The graphical approach



$$P(F) = P_1 + (P_2 \cdot P_3 \cdot P_4) + [(P_5 + P_6) \cdot P_7 \cdot (P_8 + P_9 + P_{10})]$$

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Figure 8-1. Example of the Graphical Representation of a Probability Math Model.

would be less than meaningful since adequate description of events could not be provided The equations, of course, provide all the same information as the graphical representation. In addition, each path of failure can be treated independently by a separate probability equation and full description of probability events can be provided.

All the math model equations for the localizer and glideslope are tabulated in appendices E and F respectively. Each contains two different sections - the "loss of signal" probabilities and the "hazardous signal radiation" probabilities. The probability expressions were formulated by considering each and every hazardous failure mode listed in the failure analysis. Like events (failure mode failure rates of similar failure effects) were grouped together whenever possible. For each separate probability expression listed, all failure modes in the failure analysis can be identified by failure rate subscripts. For some probability calculations, preventive maintenance cycles, which are listed in the "remarks" column, must be assumed. The reason for this is that a failure which does not cause a monitor alarm (a "hidden" failure) can only be located by periodic preventive maintenance procedures. Worst case probabilities are often given whenever the numerical result proves to be negligible. This is done solely for simplification purposes.

9.0 PREVENTIVE MAINTENANCE

One of the secondary objectives of this analysis is to provide a recommendation of how often preventive maintenance checks for hidden equipment failures should be performed to ensure a high degree of system integrity. This is a natural output for the FMECA because preventive maintenance frequencies must be utilized in the math models.

To determine the frequency of preventive maintenance checks, two factors (or requirements) must be considered: (1) an allowable probability of failure occurrence; and (2) an allowable frequency of preventive maintenance so that total mean preventive maintenance time (MPMT) does not exceed equipment specification requirements. The recommended frequency then will be a suitable compromise between these two requirements. Whenever such a compromise cannot be attained (either or both requirements cannot be fulfilled), equipment design changes must be accomplished to reduce the probability of failure.

In practice, a reasonable frequency is assumed in the math models and then the total MPMT is calculated to verify that the requirement is not exceeded. In assuming a preventive maintenance frequency, the time to perform the hidden failure check must also be considered. The charts showing the recommended preventive maintenance task frequencies for the localizer and glideslope are respectively given in appendices G and H. These charts incorporate the assumed frequencies utilized in the math model calculations. In addition to the hazardous failure modes considered in the math models, non-hazardous hidden failures identified in the failure analyses are also presented in the tables so that the overall MPMT can be calculated. A brief description of the preventive maintenance task is also provided in the charts in order to estimate the time required to perform the hidden failure check. Whenever one check can be performed simultaneously with another, its estimated task time is omitted from the table.

The sole purpose of these charts is to provide a listing of the recommended frequencies of preventive maintenance checks for hidden failures and to show that these are consistent with preventive maintenance requirements. They are not intended to be used per se by field technicians. Preventive maintenance procedures that are to be used in the field should be much more detailed. However, the frequencies provided by these charts should be an input for writing the actual field procedures.

10.0 REMOTE CONTROL/STATUS DISPLAY

The status display unit is similar to the remote control unit except that it does not possess transmitter cycle capabilities and does not have a telephone. Hence, any analysis of the remote control unit services equally well for the status display unit. A simplified functional block diagram of the remote control unit is given in figure 10-1. As seen in the diagram, only one control signal for each station is an output from the unit. All other signals pertain to status only and as such cannot affect the actual radiated signal. The cycle control line failure mode is treated

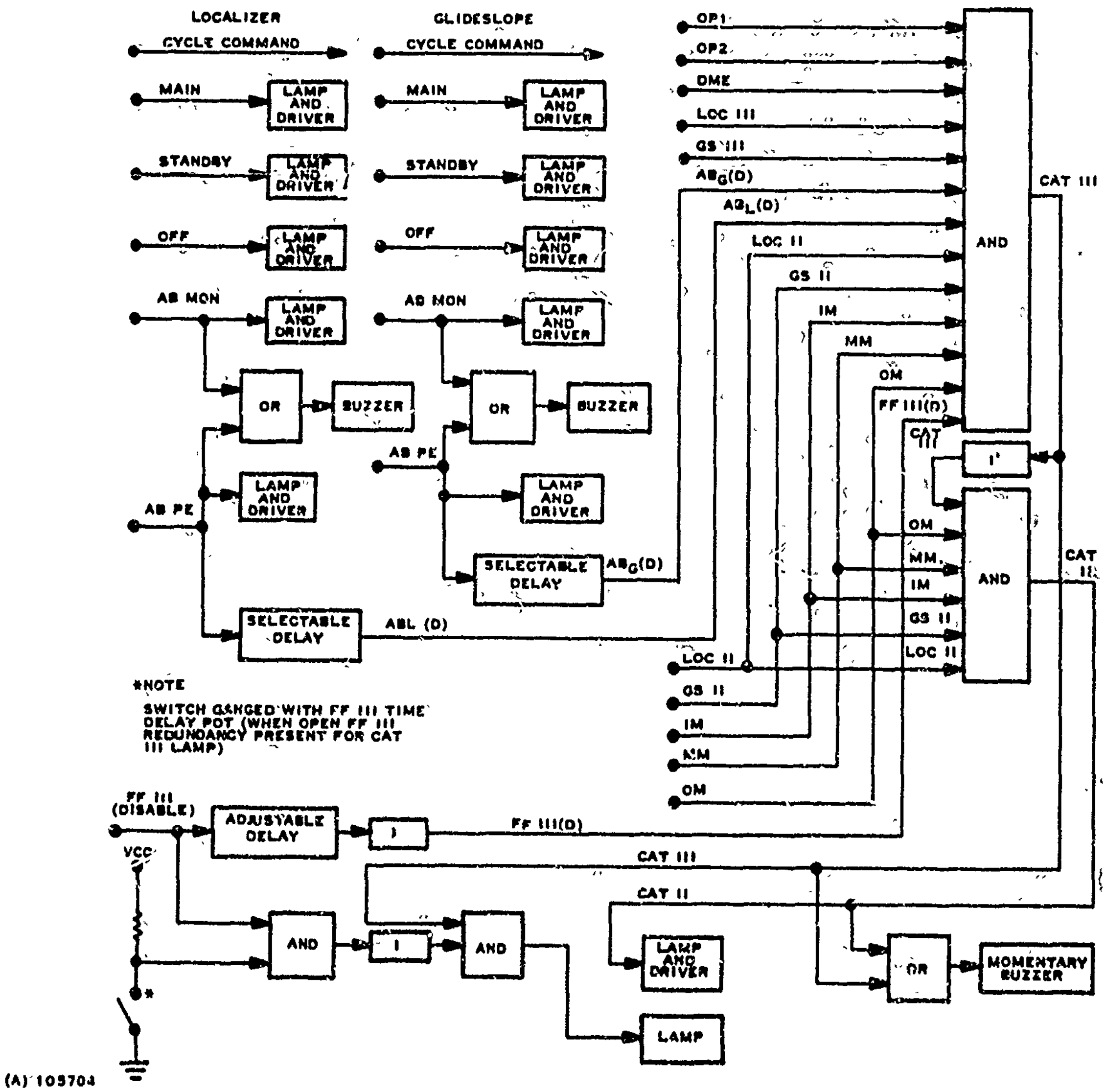

Figure 10-1. Remote Control Unit

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within the framework of control unit failure modes for each station; hence, only an analysis of status signals is necessary.

A detailed analysis of this unit is not necessary since the FMECA pertains only to a Category III performance status analysis. From an intuitive standpoint, only two revalant failure modes exist for the unit: (1) circuit failures causing the Category III performance lamp to be extinguished; and (2) circuit failures causing the Category III performance lamp to remain "on" continuously, regardless of station performance. The first of these failure modes is not hazardous. If an aircraft is just beginning (or already in) the critical landing phase, a safe Category III landing may be accomplished since the radiated signal is unaffected. Although station failures could conceiveably occur within that same 10 second critical landing phase period, the probability is totally negligible. The maximum probability of this event is given by the expression:

$$P_{MAX} = P_{REQUIREMENT} \cdot (\lambda_{RC1} \cdot 10sec)$$

where $P_{REQUIREMENT} = 1 \times 10^{-7}$ (specified)

and λ_{RC1} is the failure rate of the remote control unit circuitry that can cause the lamp to be extinguished.

To simplify matters, let $\lambda_{RC1} = 100 \times 10^{-6}$ failures per hour as worst case. Then,

$$P_{MAX} = (1 \times 10^{-7})\,(100 \times 10^{-6})\,(10/3600)$$
$$= 2.777 \times 10^{-14}$$

The second failure mode, circuit failures causing the Category III performance lamp to remain lit, is potentially hazardous since the "true" status of the radiated signal is not recognizable. However, if it is assumed that the operator check the transmitter status of each station prior to a Category III landing, the severity of the hazardous condition is greatly reduced. In face, the only potentially hazardous condition that then can exist is that the localizer signal be out of Category III tolerance at the far field. All other potentially hazardous conditions are recognizable through other status indications on the remote control unit. The reason for this is that the far field Category III disable signal affects only category performance status. It is not processed by the localizer station and, hence, there is no redundant status display associated with it. The out-of-Category III-tolerance condition at the far field is due solely to external runway and overflight disturbances.

Since an initial evaluation of this potentially hazardous failure mode revealed its probability was too high, design changes were

incorporated to provide redundancy and, thus, lower considerably the probability of this potentially hazardous occurrence. The new probability expression is given by:

$$P_{RC2} = (\lambda_{RC2} \cdot 168)(P_{FF_{CSE_{DDM}}}) \cdot (\lambda_{REDUND_{RC}} \cdot 168)$$

where λ_{RC2} = the failure rate of the remote control far field alarm processing circuitry which can cause the Category III performance lamp to remain illuminated, without redundancy.

$REDUND_{RC}$ = the failure rate of the redundancy circuitry that can cause the Category III performance lamp to remain illuminated.

$P_{FF_{CSE_{DDM}}}$ = 10^{-3} (assumed value) = the probability that the localizer ILS signal will be out of Category III DDM tolerance at the far field due to external runway distrubances during the critical landing phase of a Category III landing.

The calculated failure rate figures are given below:

$$\lambda_{RC2} = 1.141 \times 10^{-6} \text{ failures per hour}$$

$$\lambda_{REDUND_{RC}} = 0.268 \times 10^{-6} \text{ failures per hour}$$

Hence, the new probability is:

$$P_{RC2} = (1.141 \times 10^{-6} \cdot 168)(10^{-3})(0.268 \times 10^{-6} \cdot 168)$$
$$= 8.636 \times 10^{-12}$$

With the redundancy in the design incorporated, the probability of this potentially hazardous failure mode becomes negligible.

11.0 RESULTS/CONCLUSIONS

Overall failure probabilities are readily calculated from the math model tables by simple addition. Tables 11-1 and 11-2 enumerate the failure probabilities for the localizer and glideslope respectively. Table 11-3 provides a resultant failure probability summary. As can be seen, the overall probability of mission failure is 0.89345×10^{-7} which is less than 1×10^{-7}, the specified requirement. Hence, the primary purpose of this analysis has been accomplished.

Table 11-1. Total Localizer Hazardous Signal Probability

A. Localizer Shutdown Probabilities

1.	P_S:	3.912×10^{-8}	=	39.120×10^{-9}
2.	P_{AB}:	3.516×10^{-14}	=	0.000×10^{-9}
3.	P_{AC}:	1.227×10^{-11}	=	0.012×10^{-9}
4.	P_{AD}:	9.226×10^{-13}	=	0.001×10^{-9}
5.	$P_{STBY\ CSE}$:	1.722×10^{-14}	=	0.000×10^{-9}
6.	$P_{STBY\ SEN}$:	2.982×10^{-15}	=	0.000×10^{-9}
7.	$P_{STBY\ CL}$:	1.802×10^{-14}	=	0.000×10^{-9}
8.	$P_{STBY\ ID}$:	1.665×10^{-16}	=	0.000×10^{-9}
9.	P_{STBY}:	9.837×10^{-15}	=	0.000×10^{-9}
10.	$P_{PS/CONV}$:	9.906×10^{-11}	=	0.099×10^{-9}
11.	$P_{CSE/ID}$:	5.106×10^{-10}	=	0.511×10^{-9}
12.	P_{SEN}:	2.090×10^{-10}	=	0.209×10^{-9}
13.	P_{CL}:	4.540×10^{-10}	=	0.454×10^{-9}
14.	P_{NF}:	1.422×10^{-10}	=	0.142×10^{-9}
15.	P_{FF}:	6.081×10^{-10}	=	0.608×10^{-9}
16.	P_{INHIB}:	6.822×10^{-9}	=	6.822×10^{-9}
		$P_{SD} = \Sigma A$	=	47.978×10^{-9}

Table 11-1. Total Localizer Hazardous Signal Probability (continued)

B. Localizer Hazardous Signal Radiation Probabilities

1.	$P(HS)_{CSE\ DDM}$:	1.287×10^{-15}	=	0.000×10^{-9}
2.	$P(HS)_{FF}$:	5.555×10^{-10}	=	0.556×10^{-9}
3.	$P(HS)_{CSE\ DDM}$:	4.971×10^{-10}	=	0.497×10^{-9}
4.	$P(HS)_{CSE\ RF}$:	1.502×10^{-9}	=	1.502×10^{-9}
5.	$P(HS)_{SEN}$:	1.354×10^{-10}	=	0.135×10^{-9}
6.	$P(HS)_{CL\ DDM}$:	3.584×10^{-9}	=	3.584×10^{-9}
		$P_{HS} = \Sigma B$	=	6.274×10^{-9}

$$P_{TOTAL_{LOCALIZER}} = P_{SD} + P_{HS} = 54.252 \times 10^{-9} = 0.54252 \times 10^{-7}$$

Table 11-2. Total Glideslope Hazardous Signal Probability

A. Glideslope Shutdown Probabilities

1.	P_S:	2.197×10^{-8}	=	21.970×10^{-9}
2.	P_{AB}:	2.691×10^{-15}	=	0.000×10^{-9}
3.	P_{AC}:	5.884×10^{-12}	=	0.006×10^{-9}
4.	P_{AD}:	1.503×10^{-15}	=	0.000×10^{-9}
5.	$P_{STBY\ CSE}$:	9.045×10^{-15}	=	0.000×10^{-9}
6.	$P_{STBY\ SEN}$:	1.648×10^{-15}	=	0.000×10^{-9}
7.	$P_{STBY\ CL}$:	2.282×10^{-15}	=	0.000×10^{-9}
8.	P_{STBY}:	2.314×10^{-15}	=	0.000×10^{-9}
9.	P_{CONV}:	1.814×10^{-13}	=	0.000×10^{-9}
10.	P_{CSE}:	1.815×10^{-10}	=	0.182×10^{-9}
11.	P_{SEN}:	1.035×10^{-10}	=	0.104×10^{-9}
12.	P_{CL}:	1.908×10^{-10}	=	0.191×10^{-9}
13.	P_{NF}:	1.403×10^{-10}	=	0.140×10^{-9}
14.	P_{INHIB}:	3.411×10^{-9}	=	3.411×10^{-9}
		$P_{SD} = \Sigma A$	=	26.044×10^{-9}

Table 11-2. Total Glideslope Hazardous Signal Probability (continued)

B. Glideslope Hazardous Signal Radiation Probabilities

1.	$P(HS)_{CSE\,DDM}$:	8.989×10^{-16}	=	0.000×10^{-9}
2.	$P(HS)_{CSE\,SDM}$:	4.558×10^{-10}	=	0.456×10^{-9}
3.	$P(HS)_{CSE\,RF}$:	1.248×10^{-9}	=	1.248×10^{-9}
4.	$P(HS)_{SEN}$:	1.518×10^{-10}	=	0.152×10^{-9}
5.	$P(HS)_{CL}$:	1.427×10^{-9}	=	1.427×10^{-9}
6.	$P(HS)_{ATM}$:	5.806×10^{-9}	=	5.806×10^{-9}
		$P_{HS} = \Sigma B$	=	9.089×10^{-9}

$$P_{TOTAL_{GLIDESLOPE}} = P_{SD} + P_{HS} = 35.110 \times 10^{-9} = 0.35110 \times 10^{-7}$$

Table 11-3. Probability Summary

A. Localizer:	
(1) Shutdown (Loss of Radiated Signal):	47.978×10^{-9}
(2) Radiation of Hazardous Signal :	6.274×10^{-9}
B. Glideslope:	
(1) Shutdown (Loss of Radiated Signal):	26.004×10^{-9}
(2) Radiation of Hazardous Signal :	9.089×10^{-9}
C. Total	89.345×10^{-9}
	or 0.89345×10^{-7}

To achieve this primary objective, however, circuit design changes/modifications as dictated by the FMECA had to be accomplished. The following is a listing of these changes/modifications.

1. The SDM strap option will be employed for the localizer near field and far field monitor channels. The SDM alarm limits, however, will not be to Category III limits, but rather to some less stringent value which will provide an alarm output when a total loss of input signal exists. The SDM and DDM alarms will be "or'd" internal to the monitor channel, thus providing one general alarm output for alarm processing in the control

unit. The SDM strap option will also be utilized for the glideslope near field monitor channels.

2. If a continuous main monitor inhibit is generated in the control unit, a downgrading of category status indication (neither Category III or II) will occur at the remote control unit. In this way total loss of all monitoring due to inhibit circuitry failures will be remotely recognizable.

3. Additional redundancy in the far field monitor combining logic has been employed to reduce the probability of the loss of the far field Category III monitoring capability.

4. Redundancy circuitry has been incorporated in the control unit to provide direct remote status indication (performance category downgrade) whenever a "transfer condition" exists. This redundancy significantly reduces the probability of radiating a hazardous signal due to control unit processing circuit failures.

5. Redundancy has been employed in the remote control/status displays units to extinguish the Category III performance light whenever a far field Category III disable signal occurs.

6. An antenna misalignment detector test feature has been incorporated into the design to allow for a "quick and easy" check of its integrity. This was required to comply with preventive maintenance requirements.

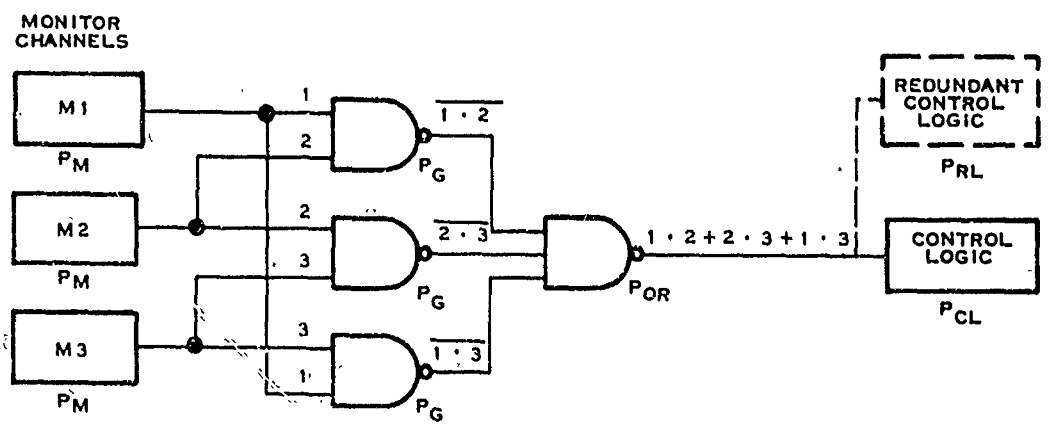
To confirm that the preventive maintenance frequencies assumed within this analysis are consistent with the requirements, a quick comparison of the assignments made in appendices G and H with the equipment specification is in order. The equipment specification states that a mean preventive maintenance time (MPMT) of one hour in 336 hours of equipment operation for any station is allowable. The total MPMT estimated for localizer hidden failures is 21.9 minutes in 336 hours of equipment operation; the total MPMT for the glideslope hidden failures is 14.0 minutes in 336 hours of equipment operation.

As another outgrowth of the FMECA the following general discussion on redundancy has evolved:

- In the general design of electronic equipment, standard design procedures such as use of high reliability parts and minimization of circuit components do not necessarily ensure that system design is optimum from a performance standpoint. To obtain a high degree of system perfor-

mance, redundancy of equipment hardware has often been employed in design. This is a very effective means when utilized correctly. Unfortunately the full advantages of redundancy are often overlooked.

- To exhibit the optimum use of redundancy in equipment design, the examples of figures 11-1 and 11-2 are provided. Assume that each of the monitor channels monitors the same system parameter. Triplicate redundancy has been incorporated in the monitoring circuitry, requiring a 2 of 3 vote for monitor alarm processing in the control logic. Figure 11-1 illustrates the typical approach (minimum circuit complexity) utilized in circuit design (redundant control logic excluded). However, when calculating the probability of loss of the parameter monitoring ability ($P(F)_{NR}$), an interesting observation results. The desirable features of triplicate monitoring are partially lost due to the control logic and "OR" gate (P_{CL} and P_{OR} respectively). It is these circuit components that limit the reduction of the probability of failure. Hence, all the additional circuitry incorporated for triplicate monitoring is rendered partially useless in minimizing the probability of failure.



NOTE: PARTIAL REDUNDANCY

$P(F)_{NR} = P_M^2 + P_G^3 + P_{OR} + P_{CL}$

$P(F)_{NR} = 10^{-8} + 10^{-18} + 10^{-6} + 10^{-5}$

$\approx 1.1 \times 10^{-5}$ (NO REDUNDANT LOGIC)

$P(F)_R = P_M^2 + P_G^3 + P_{OR} + P_{CL} \cdot P_{RL}$

$= 10^{-8} + 10^{-18} + 10^{-6} + 10^{-5} \cdot 10^{-5}$

$\approx 10^{-6}$ (WITH REDUNDANT LOGIC)

TYPICAL VALUES

$P_M = 10^{-4}$

$P_G = 10^{-6}$

$P_{OR} = 10^{-6}$

$P_{CL} = 10^{-5}$

$P_{RL} = 10^{-5}$

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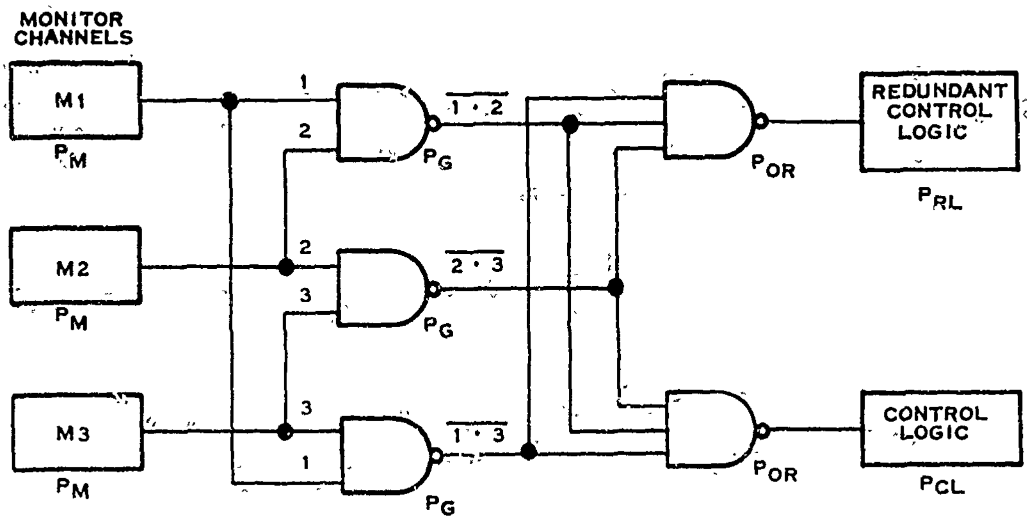
Figure 11-1. Logic Illustrating 2 of 3 Vote of Monitors for Control Processing (dashed lines illustrates partial redundancy).

- An improvement of the original design results with the additional redundant control logic (dashed lines). The new probability $(P(F)_R)$ calculation shows that there is roughly an improvement by one order of magnitude, utilizing typical values. However, as the new calculation illustrates, the true advantageous features of triplicate monitoring are still not attained. A "bottleneck" limiting factor is still present - the "OR" gate (P_{OR}).



$$
\begin{aligned}
P(F)_{RCP} &= P_M^2 + P_G^3 + P_{OR}^2 + P_{CL} \cdot P_{RL} \\
&= 10^{-8} + 10^{-18} + 10^{-12} + 10^{-5} \cdot 10^{-5} \\
&\cong 10^{-8} \text{ (WITH OPTIMUM REDUNDANCY)}
\end{aligned}
$$

(A) 105706

Figure 11-2. Logic Illustrating 2 of 3 Vote of Monitors for Control Processing with Optimum Redundancy

- Figure 11-2 is an illustration of the optimum design, utilizing redundancy. With the additional "OR" gate included, the full advantages of redundancy are attained since the limiting factor is now the monitor channels. One final observation should be pointed out concerning this matter - the addition of a single redundant gate has decreased the probability of failure two orders of magnitude, utilizing typical values. In summary then, it is vitally important to incorporate redundancy correctly if redundancy is to be incorporated at all.

The following enumerates the general conclusions resulting from the FMECA:

1. If the assumptions made within this analysis prove to be reasonably valid, the probability of either (1) a loss of signal or (2) the radiation of a potentially hazardous signal during the critical landing phase of a Category III landing is less than 1×10^{-7} for Texas Instruments Incorporated Category III ILS system. The validity of the result of the overall hazardous failure probability is enhanced since worst case analysis were often employed.

2. Single equipment failures which can lead directly to station shutdown are the major contributors which limit the reduction of the probability of a hazardous failure. Hence, to achieve further improvement of equipment design and reliability, additional redundancy in major non-redundant circuits such as the control unit is required.

3. Due particularly to the redundancy that has been incorporated into the design as a result of the FMECA, the probability of the radiation of a potentially hazardous signal has become insignificant compared to shutdown probabilities. The design modifications have made the triplicate monitoring utilized in the Category III system optimum since the "bottleneck" factor is the monitor channels themselves.

4. Since all hidden failure modes are identified in the FMECA, the results of the analysis serve as an excellent input for the writing of preventive maintenance procedures. The frequencies of these preventive maintenance checks stratified within this report are based upon allowable probabilities of occurrence and, hence, should be followed very closely in field performance.

5. Troubleshooting system failures should be greatly facilitated by utilizing both the functional block diagrams and the failure mode and effects analysis data.

12.0 REFERENCES

The references used in development of this analysis are listed below:

"Aerospace Recommended Practice 926", Society of Automotive Engineers, Inc., New York, New York, September 15, 1967.

"Annex 10 - Aeronautical Telecommunications, Volume I", International Civil Aviation Organization, 2nd Edition, April 1968.

"RADC Reliability Notebook, Volume II", Technical Report No. RADC-TR-67-108, September 1967.

"Reliability Engineering", ARINC Research Corporation, Prentice Hall, 1964.

"Reliability Requirements for Safe All Weather Landings"; Adkins, L. A.; Thatro, M. C.; Proceedings of the 7th Reliability and Maintainability Conference, San Francisco, California, July 14-17, 1968.

Appendix A

Localizer Detailed Functional Block Diagrams

Appendix A

Localizer Detailed Functional Block Diagrams

This appendix consists of detailed functional block diagrams for the localizer. Figures A-4 through A-19 cover the numbered blocks in figures A-1 and A-2 (localizer and localizer far field monitor). Figure A-3 and the accompanying table A-1 detail the localizer control unit.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3)

Name	Definition
A_{BAT}:	Alarm due to a drop in the main battery voltage.
A_{CONV}:	Alarm on one of the DC/DC converter voltages.
A_{FE_S}:	Far field shutdown alarm.
$A_{PE_{RC}}$:	Power/environmental alarm sent to remote control.
A_S:	Alarm due to standby monitors.
$A_{S(D)}$:	Alarm due to standby monitors, delayed.
A_{SM}:	Alarm due to standby monitors, memorized.
AB:	Abnormal condition signal.
AB_{MON}:	Abnormal condition signal due to monitor channel alarm.
$AB_{MON_{RC}}$:	Monitor alarm sent to remote control.
AC:	AC power alarm from one of the two battery chargers.
BC:	Battery charger alarm from one of the two chargers.
BLINK:	Blinker output signal, a square wave oscillator.
C:	Cycling command signal for transmitters.
C_{ANT}:	Command to have transmitter no. 1 connected to the antenna.
$\overline{C}_{ANT}$:	Command to have transmitter no. 2 connected to the antenna.
C_1:	Command to turn on transmitter no. 1.
C_2:	Command to turn on transmitter no. 2.
CAT II_{RC}:	Signal to remote control used to determine Category II status.
CAT III_{RC}:	Signal to remote control used to determine Category III status.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

Name	Definition
CONTROL:	Cycle command (MAIN, STBY, or OFF).
CL_{11}:	Category III DDM clearance alarm, monitor no. 1.
CL_{12}:	Category III DDM clearance alarm, monitor no. 2.
CL_{13}:	Category III DDM clearance alarm, monitor no. 3.
CL_{21}:	Category III SDM clearance alarm, monitor no. 1.
CL_{22}:	Category III SDM clearance alarm, monitor no. 2.
CL_{23}:	Category III SDM clearance alarm, monitor no. 3.
CL_{31}:	Category III RF clearance alarm, monitor no. 1.
CL_{32}:	Category III RF clearance alarm, monitor no. 2.
CL_{33}:	Category III RF clearance alarm, monitor no. 3.
CSE_{11}:	Category III DDM course alarm, monitor no. 1.
CSE_{12}:	Category III DDM course alarm, monitor no. 2.
CSE_{13}:	Category III DDM course alarm, monitor no. 3.
CSE_{21}:	Category III SDM course alarm, monitor no. 1.
CSE_{22}:	Category III SDM course alarm, monitor no. 2.
CSE_{23}:	Category III SDM course alarm, monitor no. 3.
CSE_{31}:	Category III RF course alarm, monitor no. 1.
CSE_{32}:	Category III RF course alarm, monitor no. 2.
CSE_{33}:	Category III RF course alarm, monitor no. 3.
CSE 111:	Category II DDM course alarm, monitor no. 1.
CSE 112:	Category II DDM course alarm, monitor no. 2.
CSE 113:	Category II DDM course alarm, monitor no. 3.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

Name	Definition
FF_{BY_L}:	Far field bypass local.
FF_{BY_R}:	Far field bypass remote.
FF_{MM}:	Far field mismatch.
FF_{PE}:	Far field power/environmental alarm.
FF_S:	Far field shutdown.
FF_{SA}:	Far field shutdown alert.
I_C:	Inhibit signal to inhibit transmitter cycling capability.
I_{MAIN}:	Main inhibit to main monitor channels.
I_{ON}:	Inhibit signal due to power turn-on.
I_T:	Inhibit signal due to transfer commands, either auto or manual.
I_S:	Inhibit signal due to shutdown commands, either auto or manual.
I_{STBY}:	Standby inhibit to standby monitor channels.
ID No. 1 (tone):	ID tone from ID unit no. 1.
ID No. 2 (tone):	ID tone from ID unit no. 2.
L_{AB}:	Abnormal status lamp signal.
L_{AC}:	AC power alarm status lamp signal.
L_{BAT}:	Battery alarm status lamp signal.
L_{BC}:	Battery charger alarm status lamp signal.
L_C:	DC/DC converter alarm status lamp signal.
$L_{FF_{BY}}$:	Far field bypass status lamp signal.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

Name	Definition
$L_{FF_{GO}}$:	Far field "good condition" status lamp signal.
$L_{FF_{MM}}$:	Far field monitor mismatch status lamp signal.
$L_{FF_{PE}}$:	Far field power/environmental status lamp signal.
L_{FF_S}:	Far field shutdown status lamp signal.
L_N:	Normal status lamp signal.
L_{TEMP}:	Temperature alarm status lamp signal.
L_{MLB}:	Monitors locally bypassed status lamp signal.
L_{MM}:	Monitor mismatch status lamp signal.
L_S:	Shutdown status lamp signal.
L_{X_1}:	Transmitter no. 1 connected to antenna status lamp signal.
L_{X_2}:	Transmitter no. 2 connected to antenna status lamp signal.
LOC:	Local control of transmitting unit.
LT:	Transfer signal memorized.
MA_{CL}:	Clearance monitor alarm.
$MA_{CSE_{111}}$:	Course monitor alarm, Category II alarm limits.
$MA_{CSE_{111}}$:	Course monitor alarm, Category III alarm limits.
MA_{ID}:	Monitor alarm, 2 of 3 ID monitors.
$MA_{NF(D)}$:	Near field monitor alarm which is delayed.
MA_S:	Shutdown command from monitor alarms.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

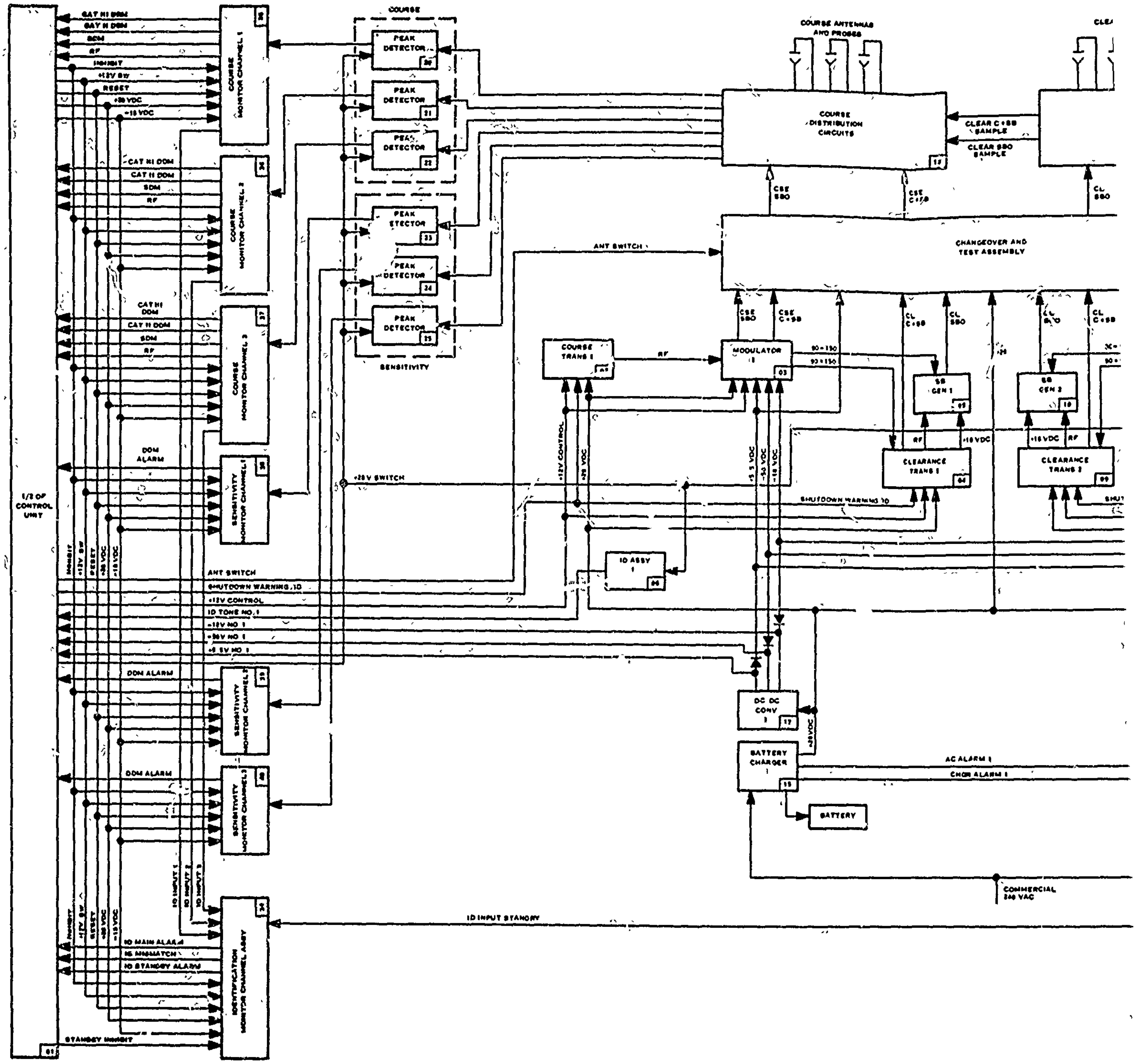
Name	Definition
MA_{SEN}:	Sensitivity monitor alarm.
MA_{T}:	Transfer command from monitor alarms.
MAIN:	Main transmitter "on" status signal.
$MAIN_{RC}$:	Signal to remote control used to determine MAIN status.
MLB:	Monitors locally bypassed.
MM_{CL}:	Clearance monitor mismatch.
$MM_{CL/NF}$:	Clearance or near field monitor mismatch.
$MM_{CSE_{III}}$:	Course monitor mismatch, Category III alarm limits.
MM_{FF}:	Far field monitor mismatch.
MM_{ID}:	Monitor mismatch, 1 of 3 I D monitors.
$MM_{NF(D)}$:	Near field monitor mismatch which is delayed.
MM_{SEN}:	Sensitivity monitor mismatch, Category III alarm limits.
NF 1:	Category II DDM near field alarm, monitor no. 1.
NF 2:	Category II DDM near field alarm, monitor no. 2.
OFF:	Both transmitters "off" status signal.
OFF_{RC}:	Signal to remote control used to determine OFF status.
ON/OFF:	Front panel control unit power supply control.
REM:	Remote control of transmitting unit.
$\overline{RESET}$:	Signal to reset alarm memory latches.
S_{CL}:	Standby clearance monitor alarm - DDM, SDM or RF with Category III limits.
S_{CSE}:	Standby course monitor alarm - DDM, SDM, or RF with Category III limits.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

Name	Definition
S_{ID}:	Standby identification monitor alarm - Category III limits.
S_M:	Shutdown signal memorized.
S_{SEN}:	Standby sensitivity monitor alarm - DDM with Category III limits.
S_0:	Both transmitter are selected to be off.
S_1:	Transmitter no. 1 is selected as main.
S_2:	Transmitter no. 2 is selected as main.
$\overline{S}_{12}$:	Selection of transmitter no. 1 memorized.
S_{12}:	Selection of transmitter no. 2 memorized.
SA_{NF}:	Shutdown alert signal due to near field monitors.
SEN_{11}:	Category III DDM sensitivity alarm, monitor no. 1.
SEN_{12}:	Category III DDM sensitivity alarm, monitor no. 2.
SEN_{13}:	Category III DDM sensitivity alarm, monitor no. 3.
STBY:	Standby transmitter "on" status signal.
$STBY_{RC}$:	Signal to remote control used to determine STANDBY status.
TEMP:	Temperature alarm inside main cabinet.
XFR:	Transfer command due to XFR1 or XFR2 (redundant for remote recognition).
XFR1:	Transfer command due to course and sensitivity (redundant).
XFR2:	Transfer command due to clearance and near field (redundant).
XMTR No. 1 (shutdown warning/ID no. 1):	Sum of shutdown alert and ID tone no. 1.

Table A-1. Definition of Signal Names (Localizer Control Unit, Figure A-3) (Continued)

Name	Definition
XMTR No. 2 (shutdown warning/ID no. 2):	Sum of shutdown alert and ID tone no. 2.
+12V CONTROL:	Control signal to turn on monitor channels.
-18V:	A common -18v from the two DC/DC converters.
-18_1:	-18 volts from converter no. 1.
-18_2:	-18 volts from converter no. 2.
+28V BATT:	The voltage of the main batteries.
$+5_1$:	+5 volts from converter no. 1.
$+5_2$:	+5 volts from converter no. 2.
-50_1:	-50 volts from converter no. 1.
-50_2:	-50 volts from converter no. 2.



1/2 OF CONTROL UNIT
COURSE MONITOR CHANNEL 1
COURSE MONITOR CHANNEL 2
COURSE MONITOR CHANNEL 3
SENSITIVITY MONITOR CHANNEL 1
SENSITIVITY MONITOR CHANNEL 2
SENSITIVITY MONITOR CHANNEL 3
IDENTIFICATION MONITOR CHANNEL ASSY
COURSE
PEAK DETECTOR
SENSITIVITY
COURSE ANTENNAS AND PROBES
COURSE DISTRIBUTION CIRCUITS
CLEAR C+SB SAMPLE
CLEAR SBO SAMPLE
CHANGEOVER AND TEST ASSEMBLY
ANT SWITCH
COURSE TRANS 1
RF
MODULATOR 1
SB GEN 1
SB GEN 2
CLEARANCE TRANS 1
CLEARANCE TRANS 2
+28V SWITCH
SHUTDOWN WARNING 1D
ID ASSY 1
+12V CONTROL
ID TONE NO. 1
DC DC CONV 1
BATTERY CHARGER 1
BATTERY
AC ALARM 1
CHGR ALARM 1
COMMERCIAL 240 VAC
ID INPUT STANDBY
DDM ALARM
ID MAIN ALARM
ID MISMATCH
ID STANDBY ALARM
STANDBY INHIBIT

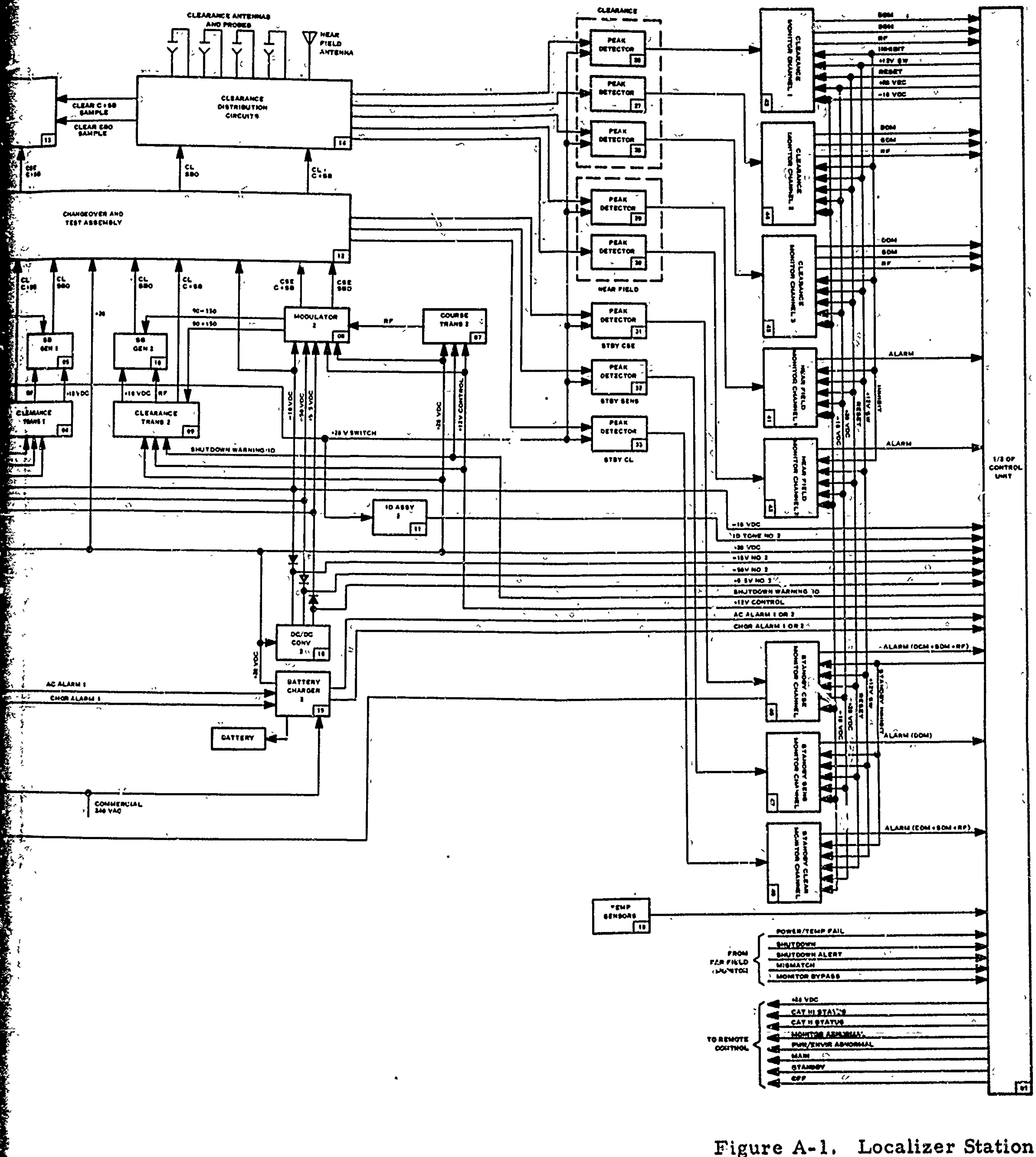
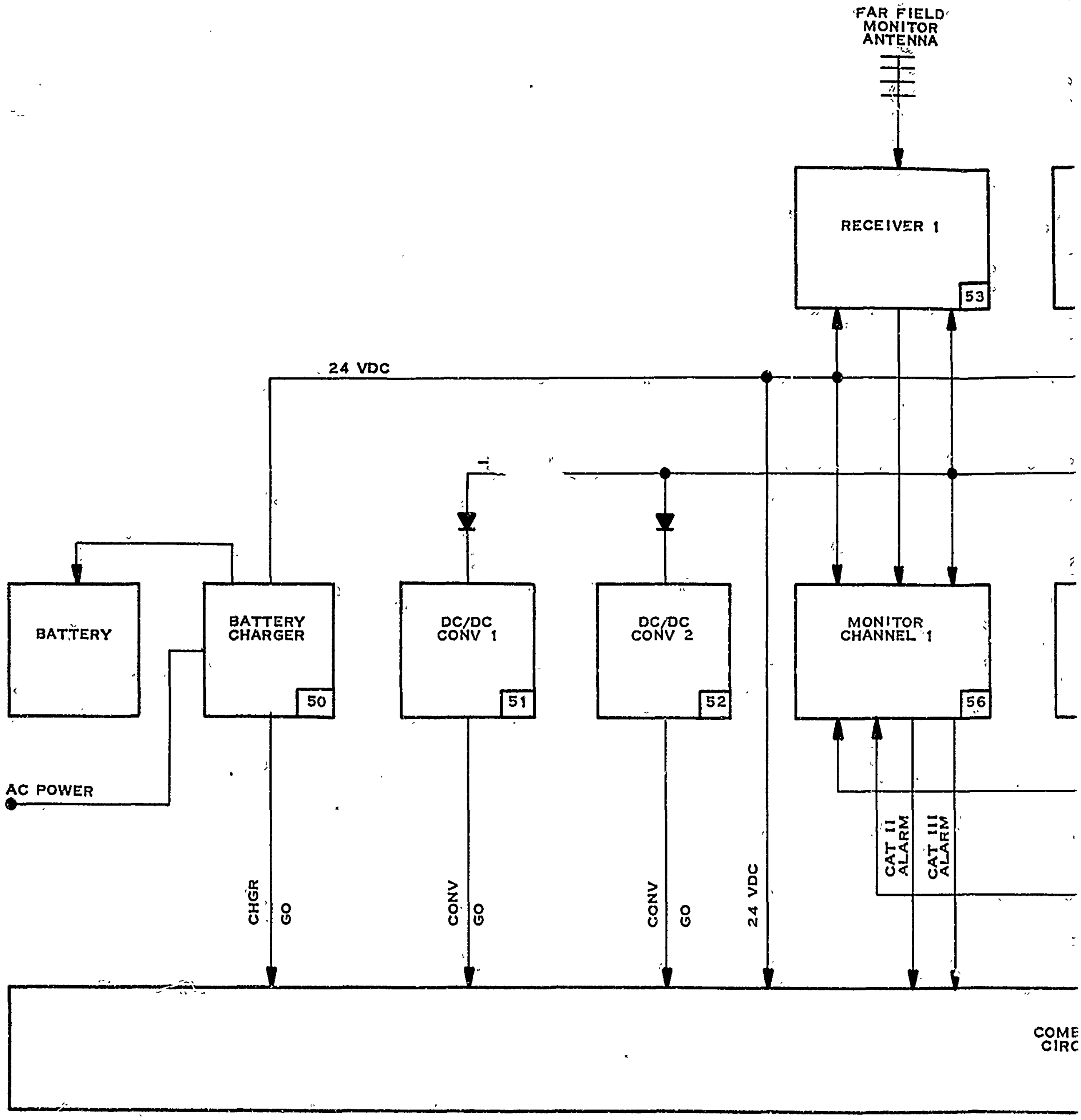


Figure A-1. Localizer Station



FAR FIELD
MONITOR
ANTENNA
RECEIVER 1
53
24 VDC
BATTERY
BATTERY
CHARGER
50
DC/DC
CONV 1
51
DC/DC
CONV 2
52
MONITOR
CHANNEL 1
56
AC POWER
CHGR GO
CONV GO
CONV GO
24 VDC
CAT II
ALARM
CAT III
ALARM
COMB
CIRC

(B) 105097A

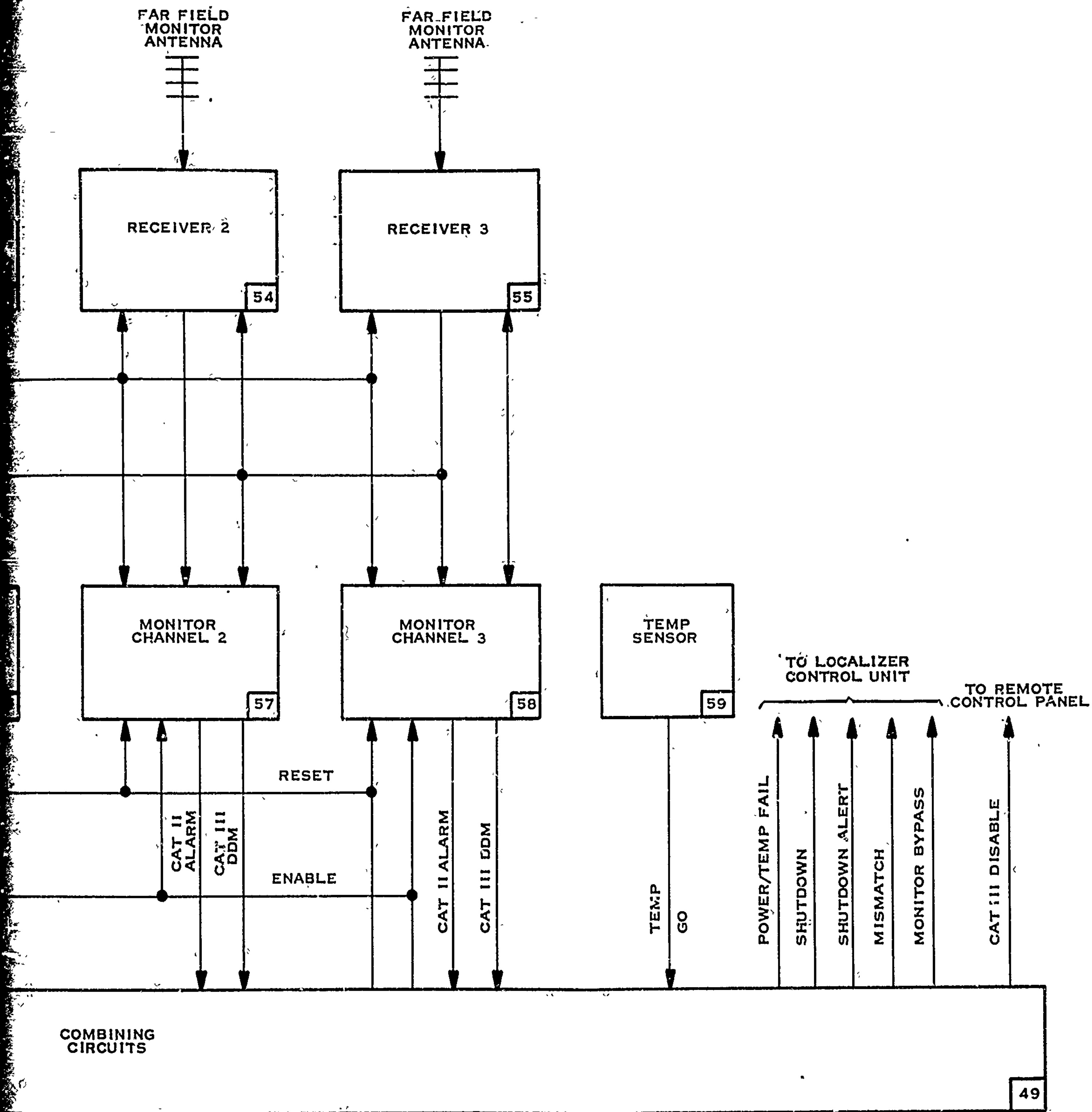
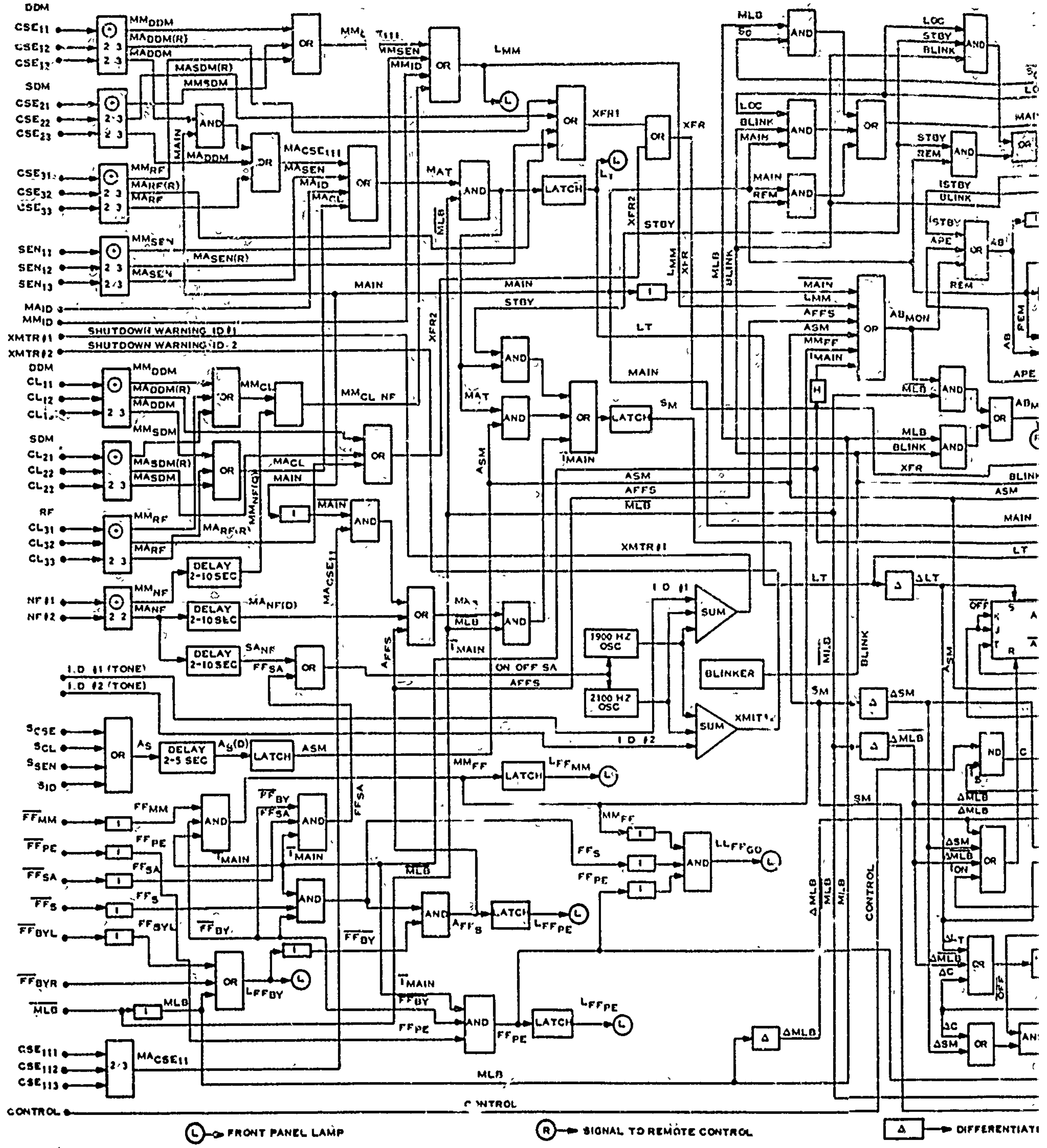


Figure A-2. Far Field Monitor


DDM
CSE11
CSE12
CSE13
SDM
CSE21
CSE22
CSE23
CSE31
CSE32
CSE33
SEN11
SEN12
SEN13
MAID
MMID
XMTR#1
XMTR#2
SHUTDOWN WARNING ID#1
SHUTDOWN WARNING ID-2
CL11
CL12
CL13
CL21
CL22
CL23
RF
CL31
CL32
CL33
NF#1
NF#2
DELAY 2-10SEC
I.D. #1 (TONE)
I.D. #2 (TONE)
SCSE
SCL
SSEN
SID
DELAY 2-5 SEC
LATCH
FFMM
FFPE
FFSA
FFS
FFBYL
FFBYR
MLB
CSE111
CSE112
CSE113
CONTROL
AND
OR
XFR1
XFR
XFR2
STBY
MAIN
LOC
BLINK
REM
LT
SM
ASM
AFFS
ABMON
1900 HZ OSC
2100 HZ OSC
SUM
BLINKER
XMIT
ON OFF SA
FRONT PANEL LAMP
SIGNAL TO REMOTE CONTROL
DIFFERENTIATI

(R) 105707

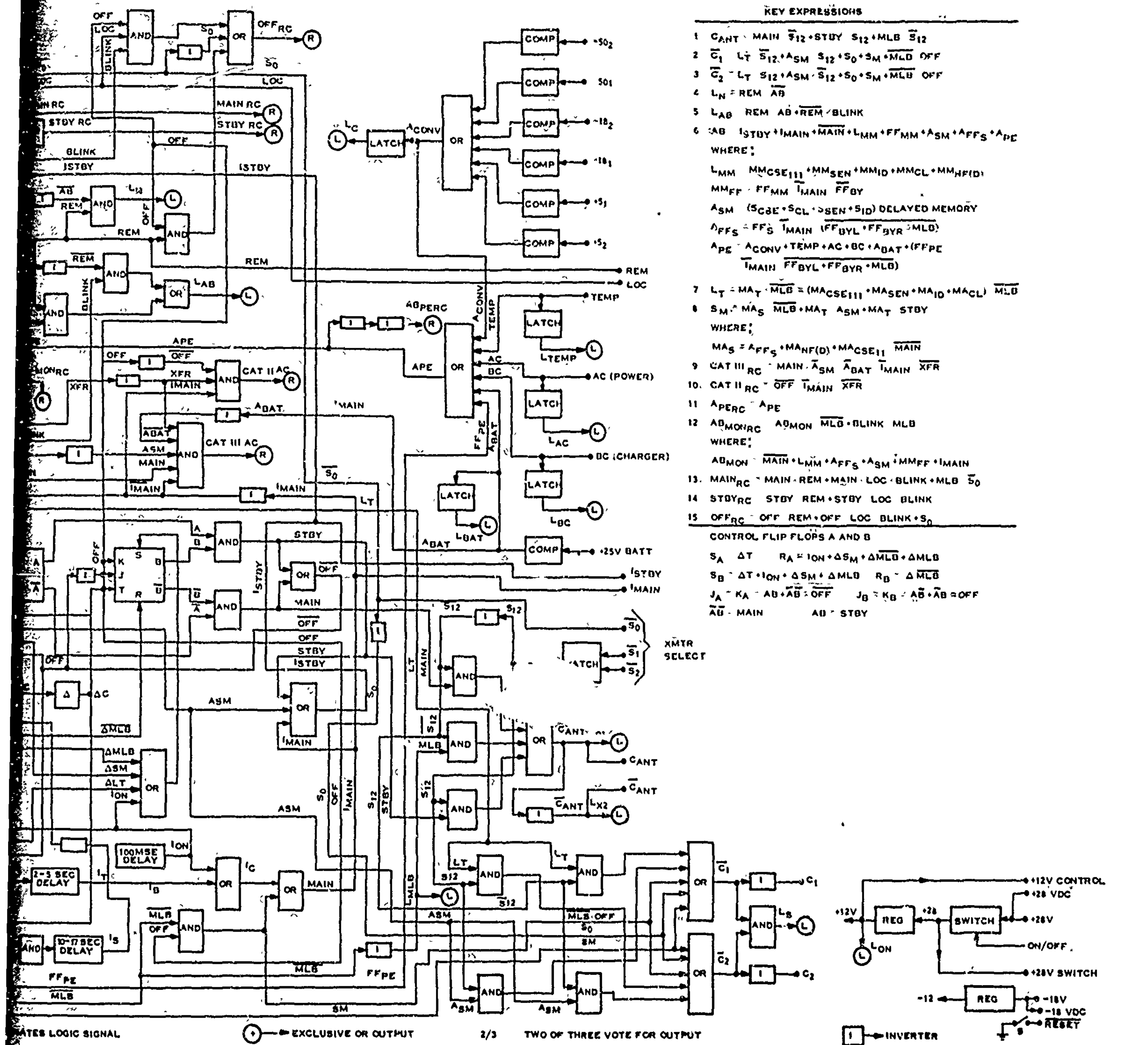
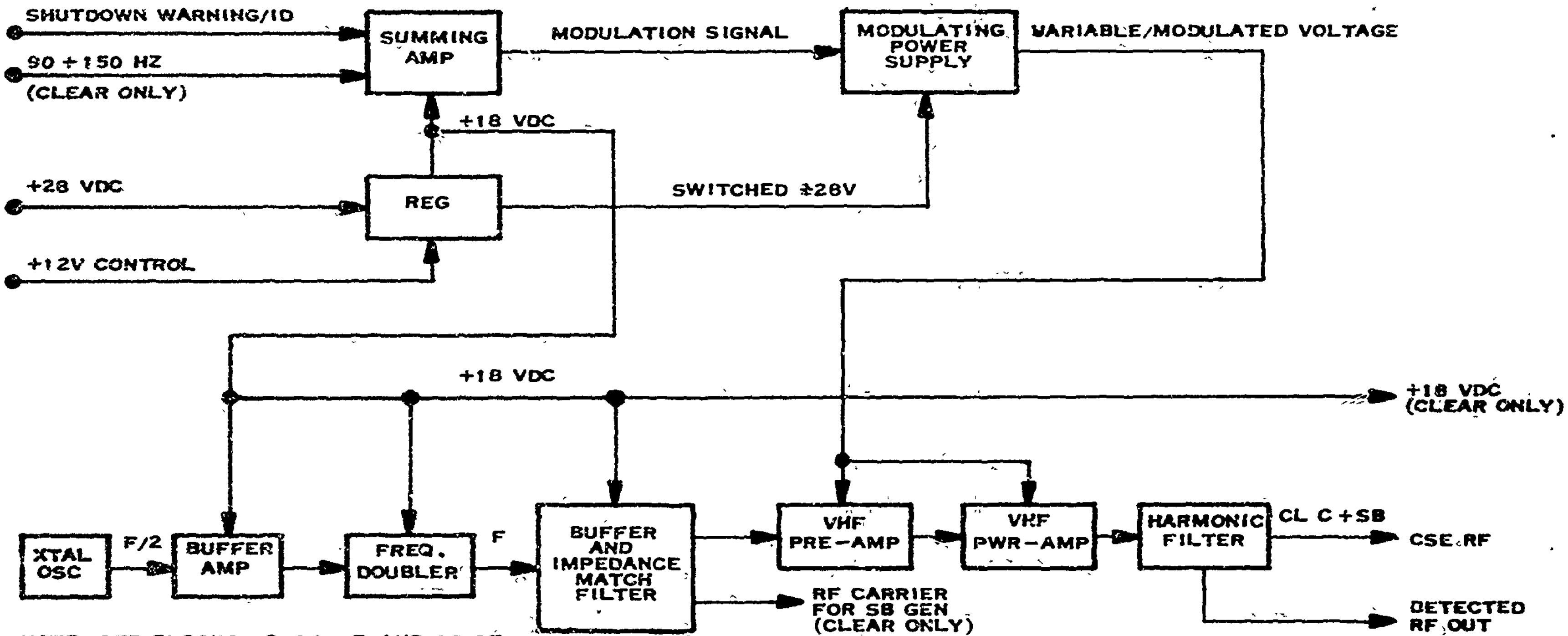


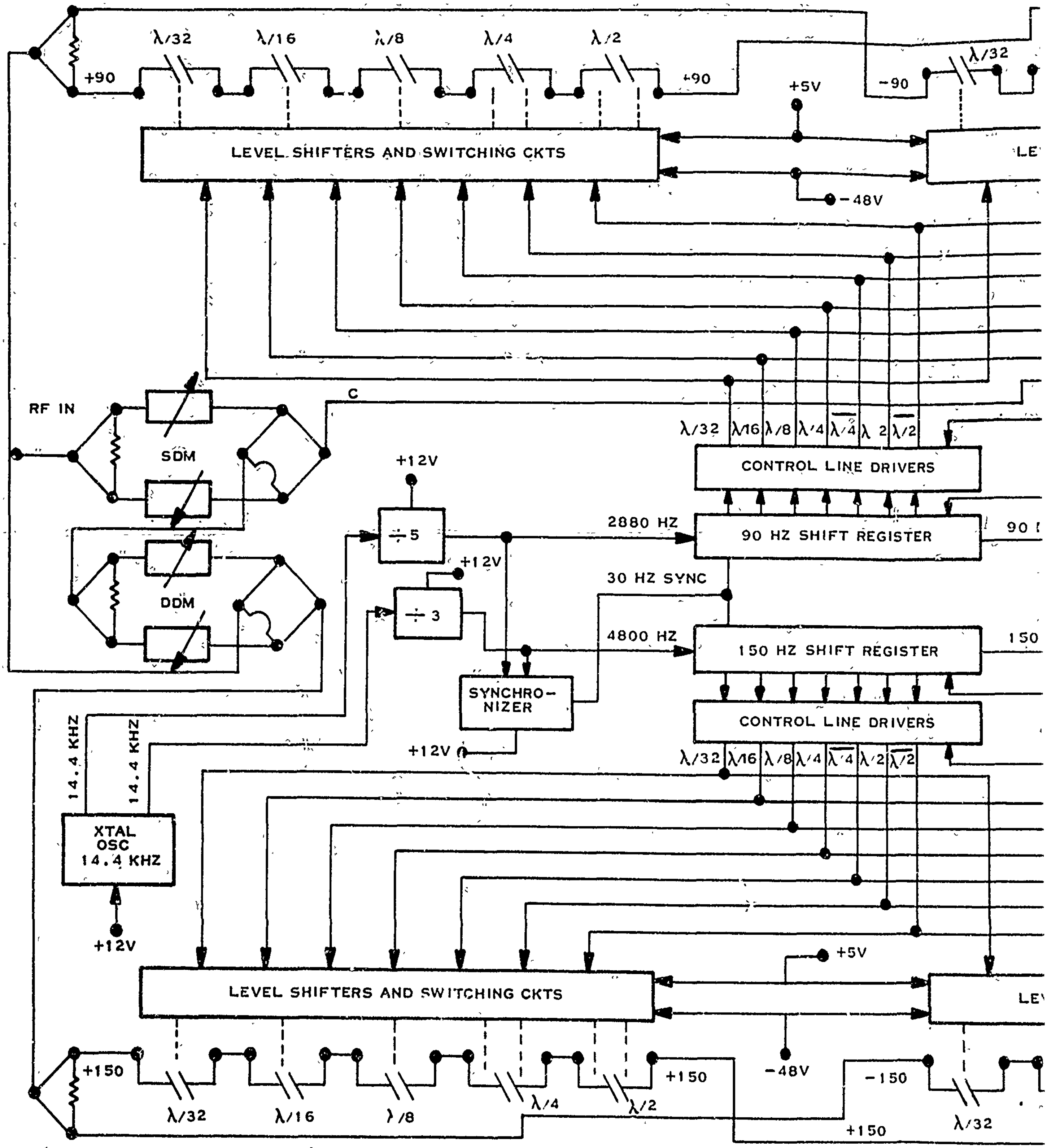
Figure A-3. Localizer Control Unit



NOTE SEE BLOCKS 02, 04, 07, AND 09 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM.

(A) 105708

Figure A-4. VHF Transmitter (Course and Clearance)



NOTE: SEE BLOCK 03 AND 08 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM.

(B) 105709

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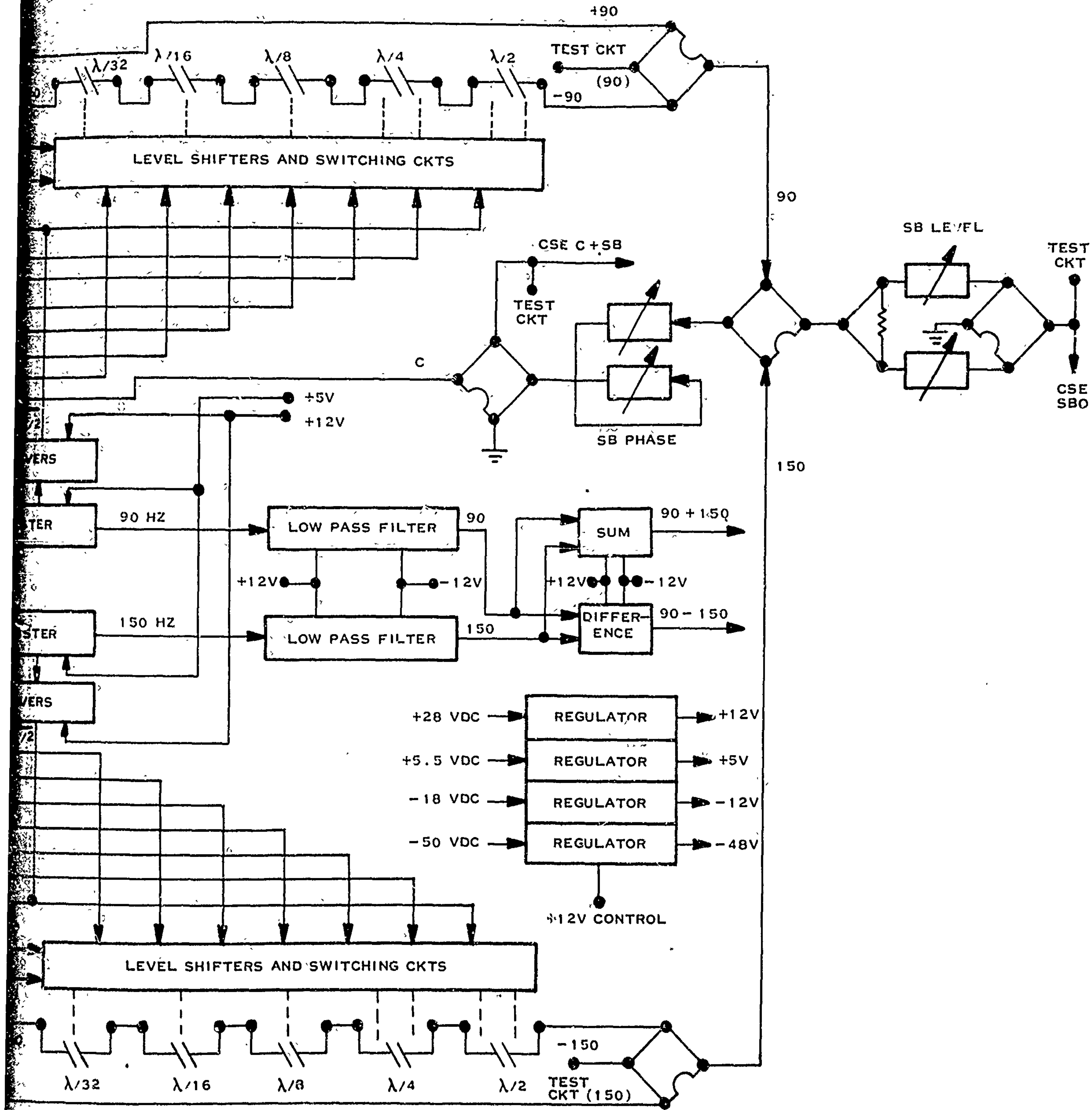


Figure A-5. VHF Modulator

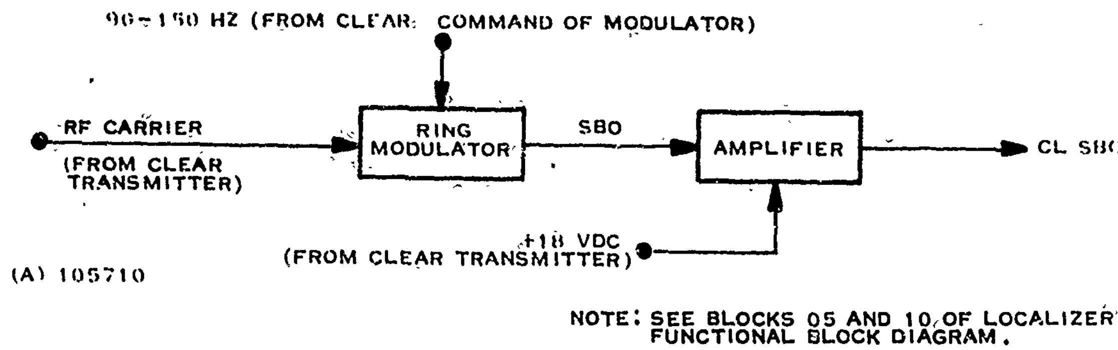


Figure A-6. Sideband Generator

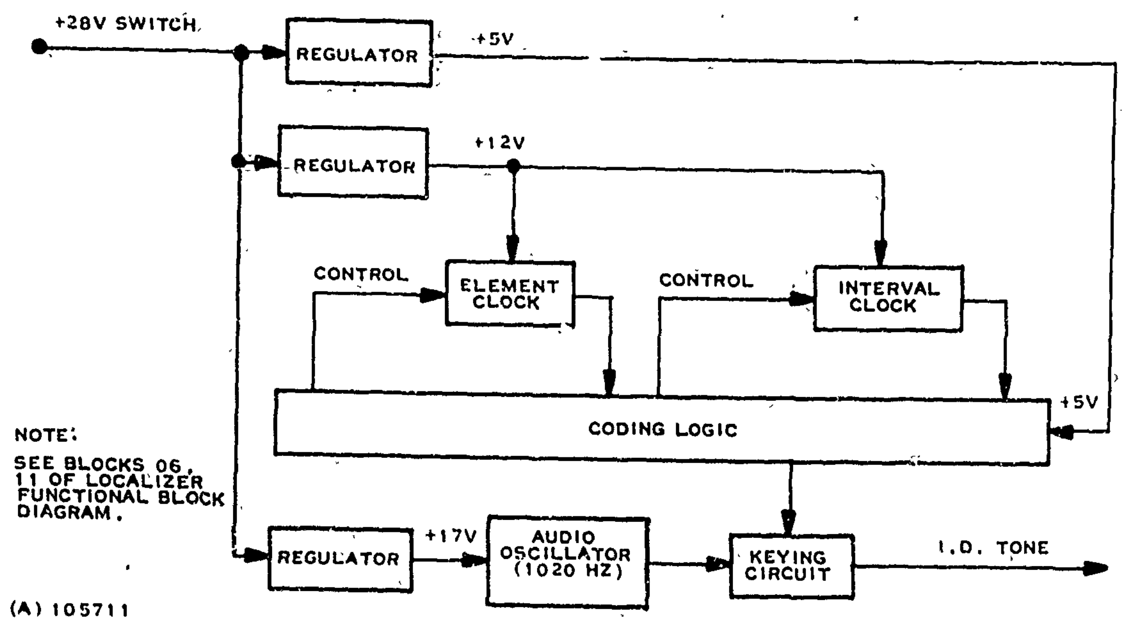


Figure A-7. Identification Unit

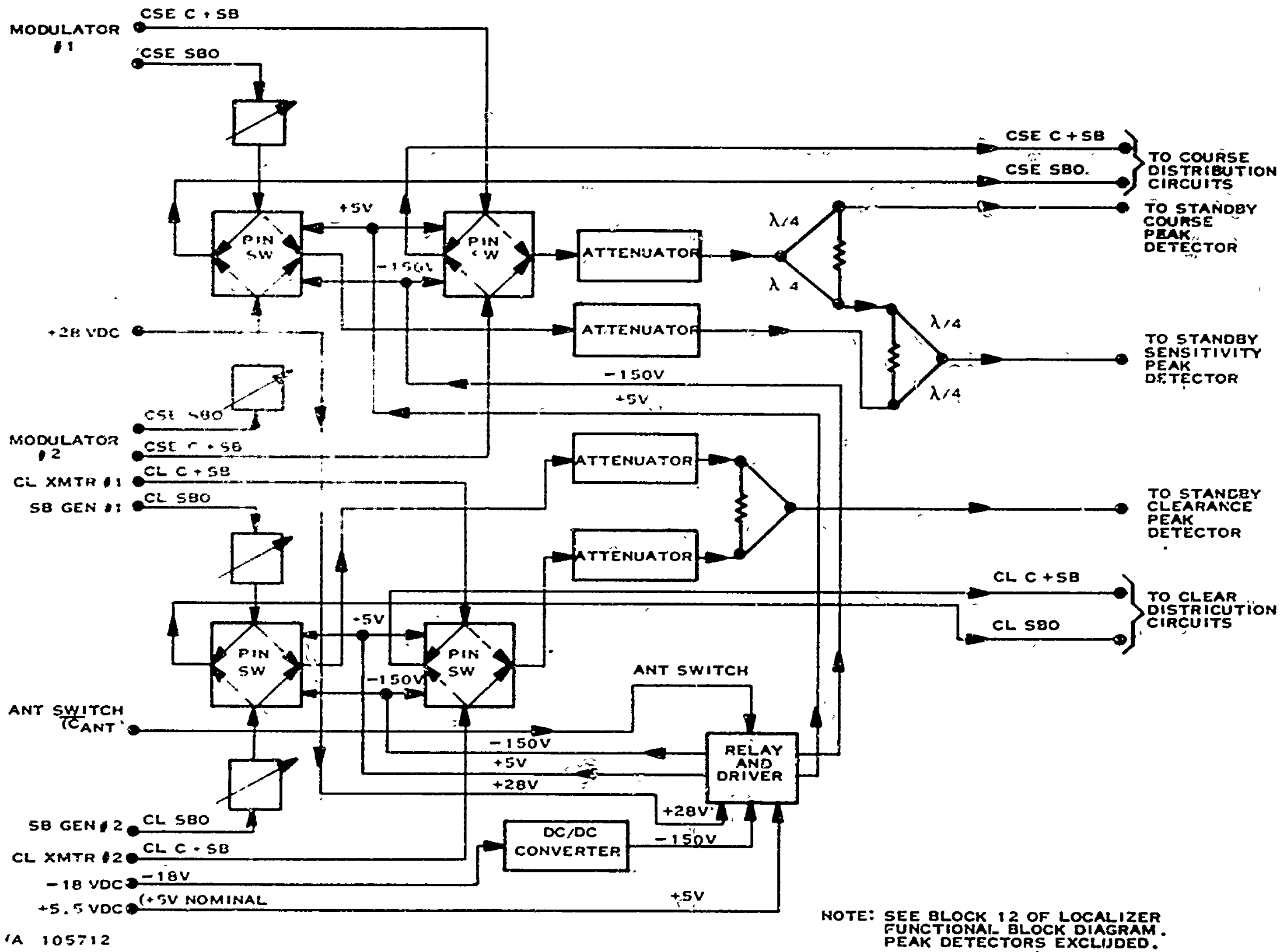
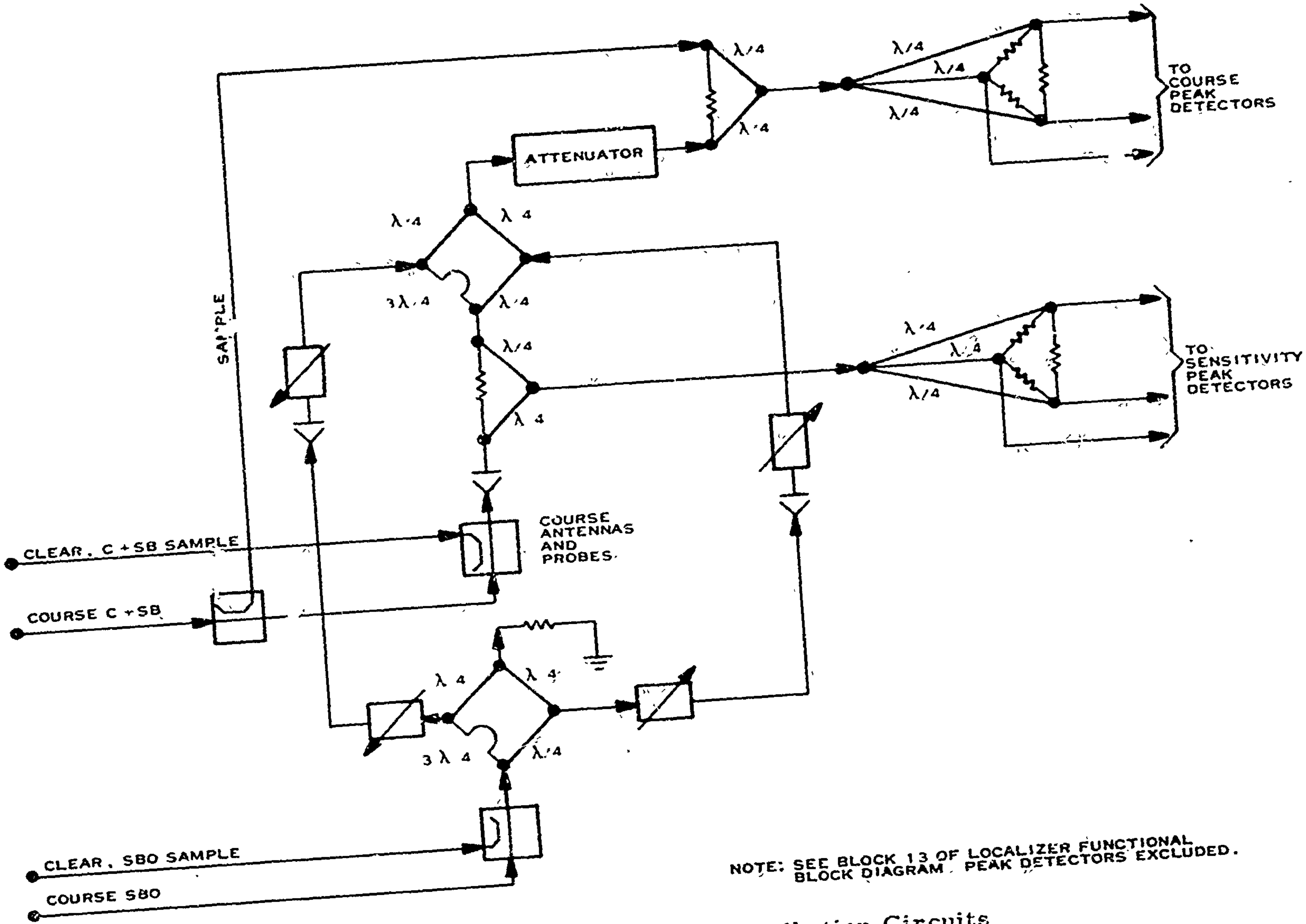


Figure A-8. VHF Changeover and Test Assembly



NOTE: SEE BLOCK 13 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM. PEAK DETECTORS EXCLUDED.

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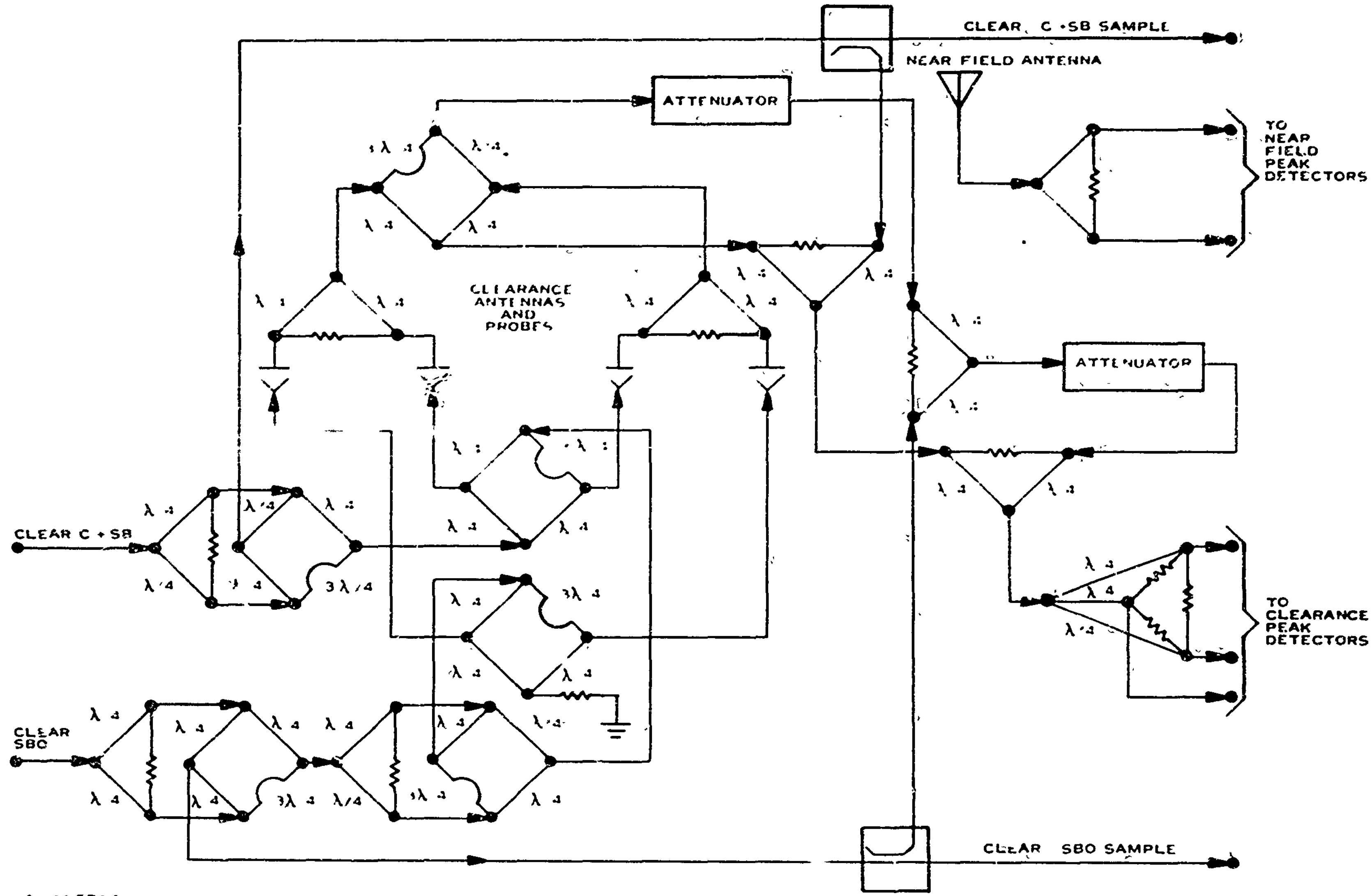
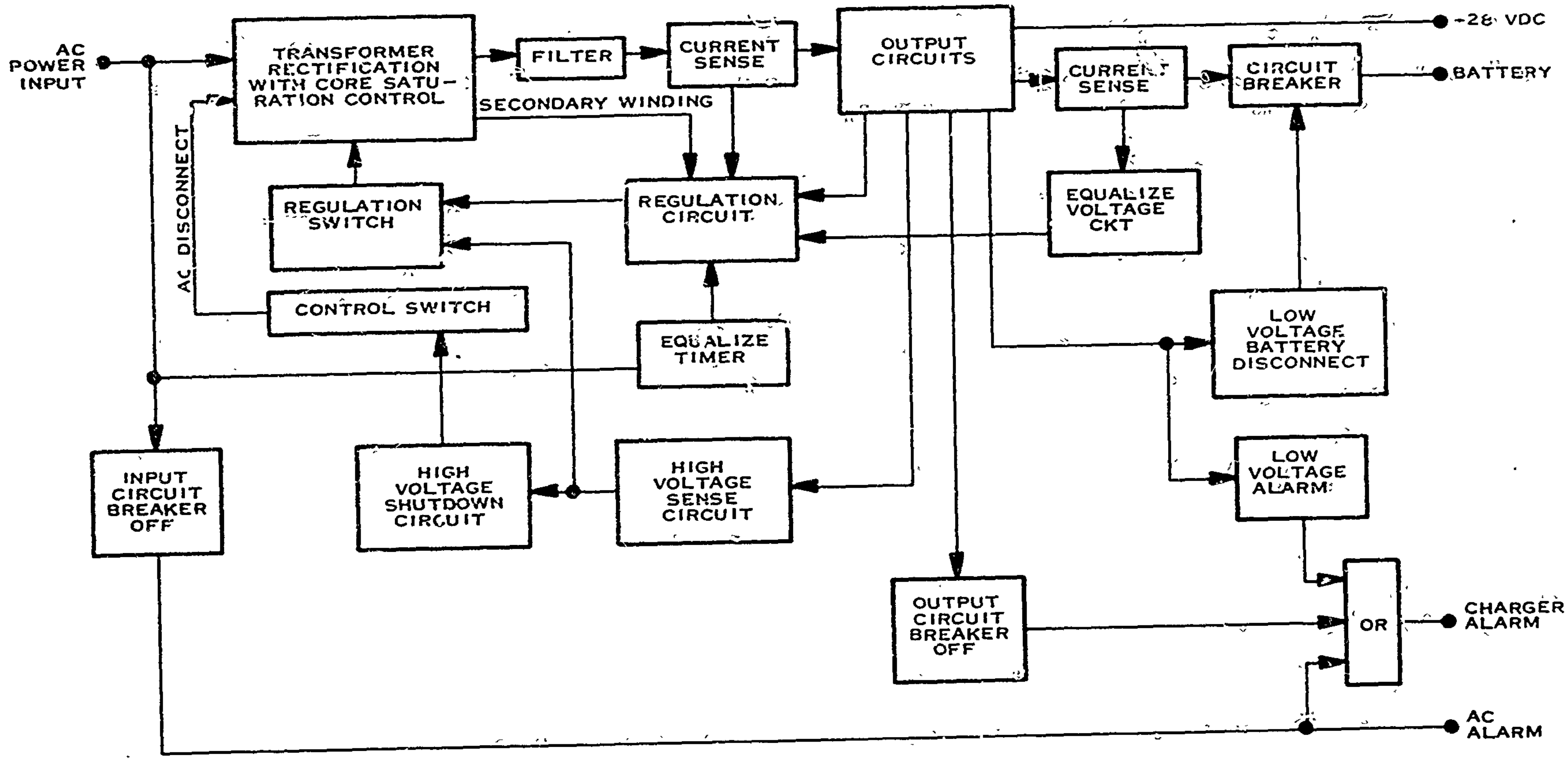
Figure A-9. VHF Course Distribution Circuits



(A) 105714

Figure A-10. VHF Clearance Distribution Circuits

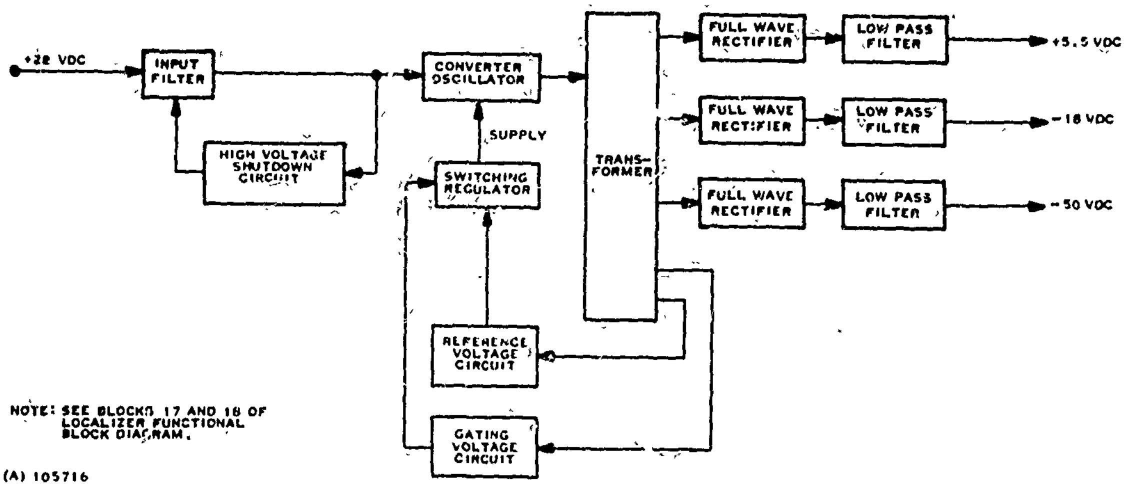


NOTE: SEE BLOCKS 15 AND 16 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAMS.

*CHARGER ALARM" AND "AC ALARM" ARE OPEN RELAY CONTACTS IN THE ALARM STATE. CLOSED NORMALLY. THE CORRESPONDING ALARMS FROM BOTH CHARGERS ARE WIRED IN SERIES.

(A) 105715

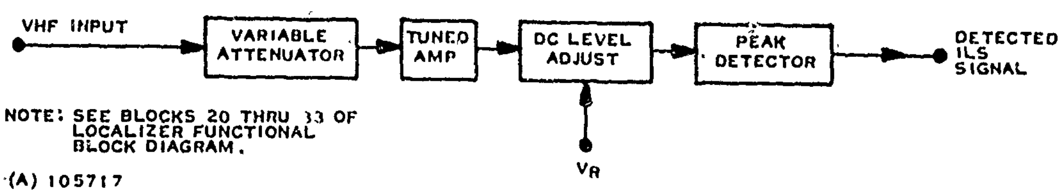
Figure A-11. Battery Charger



NOTE: SEE BLOCKS 17 AND 18 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM.

(A) 105716

Figure A-12. Dc/Dc Converter



NOTE: SEE BLOCKS 20 THRU 33 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM.

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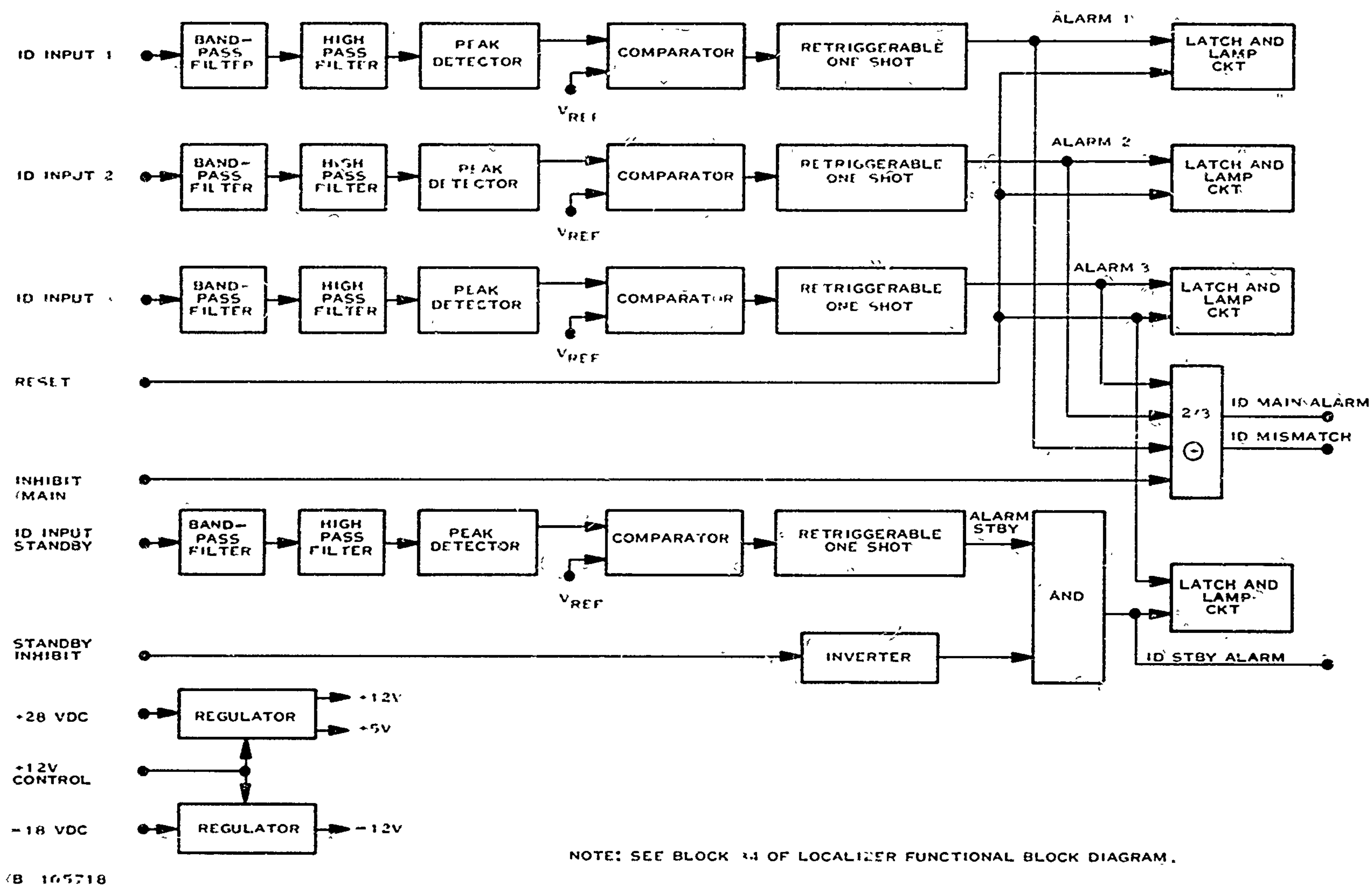
Figure A-13. VHF Peak Detectors



NOTE: SEE BLOCK 34 OF LOCALIZER FUNCTIONAL BLOCK DIAGRAM.

B 165718

Figure A-14. Identification Monitor Channel

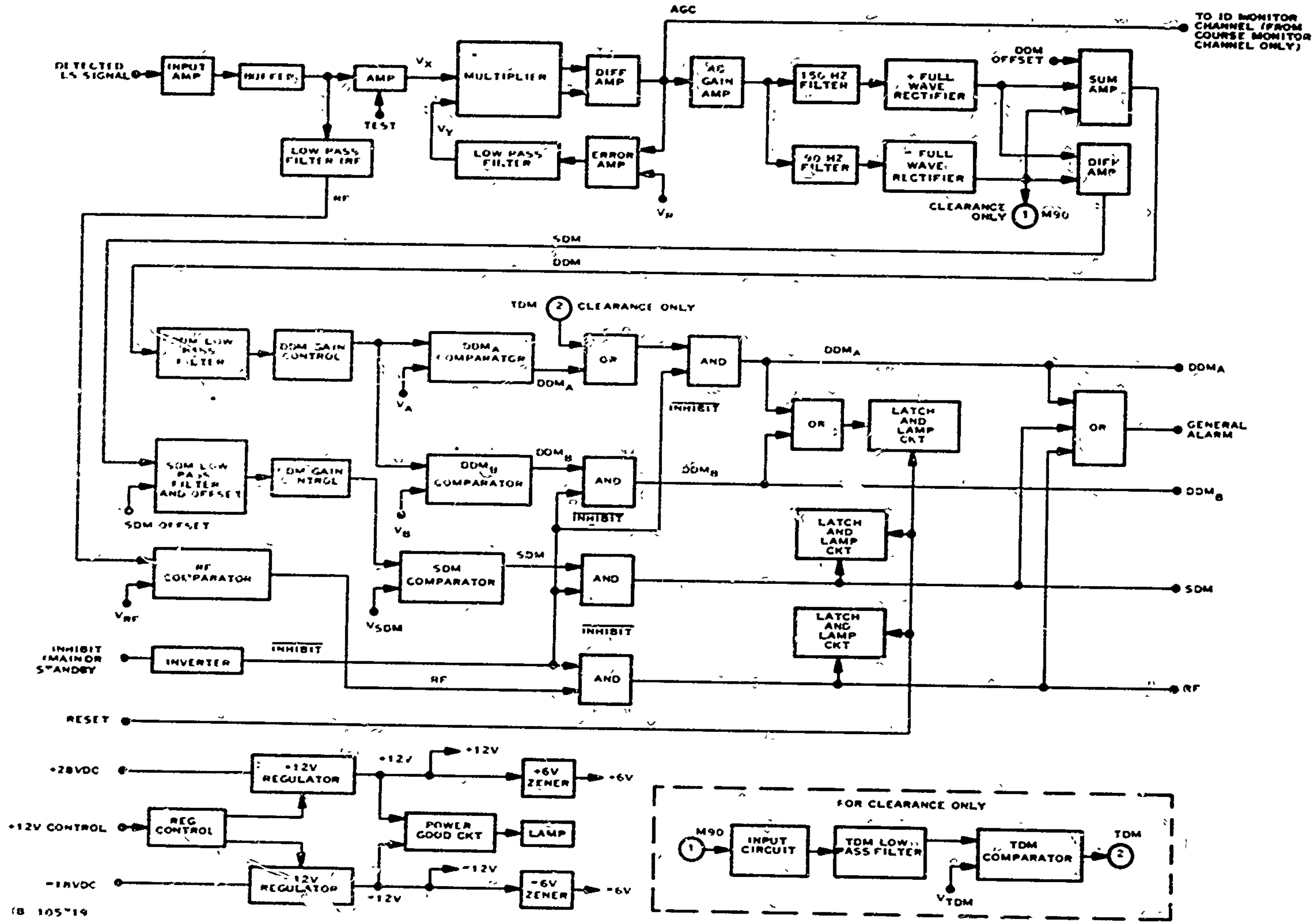


Figure A-15. Monitor Channel

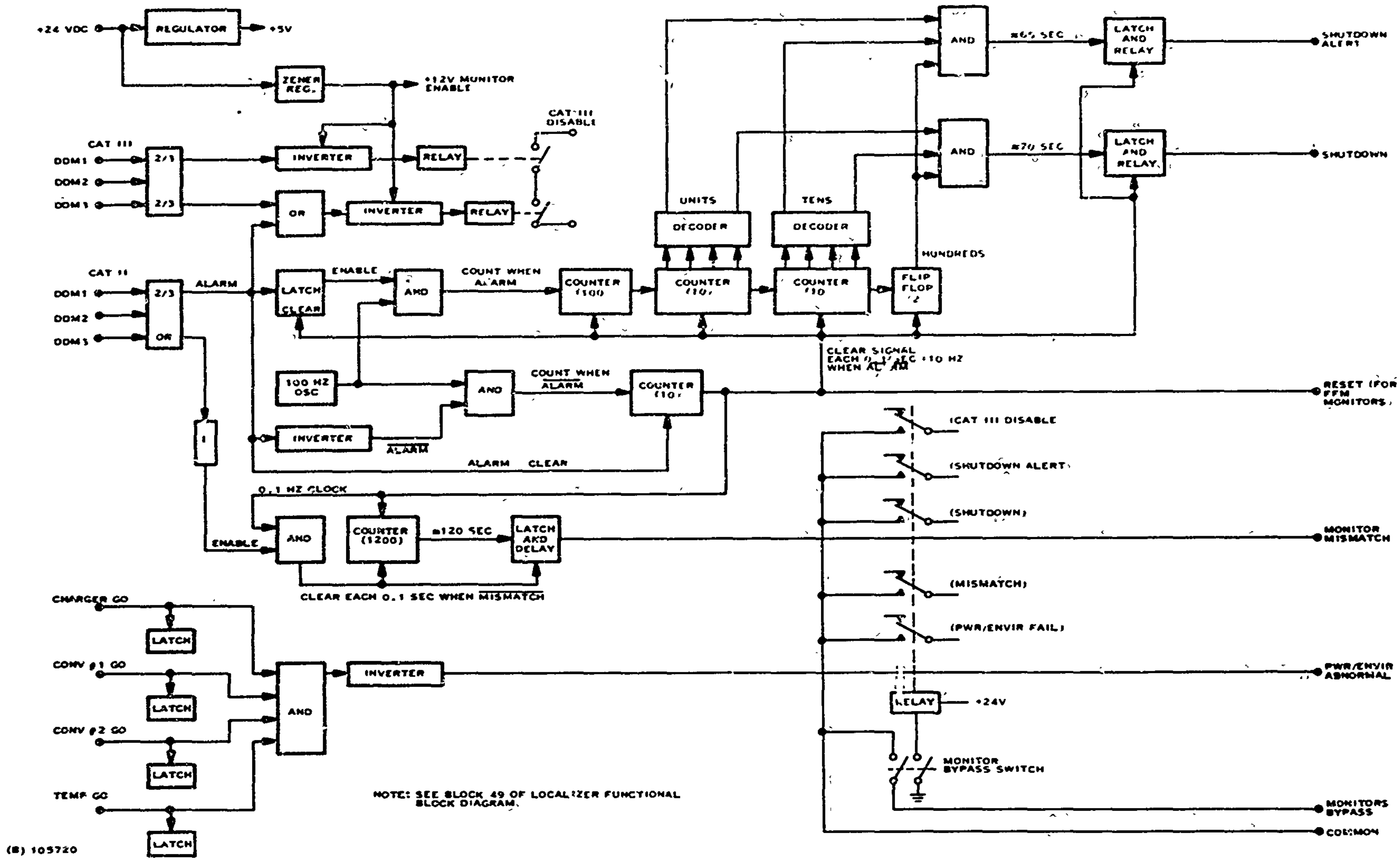


Figure A-16. Far Field Monitor Combining Circuits

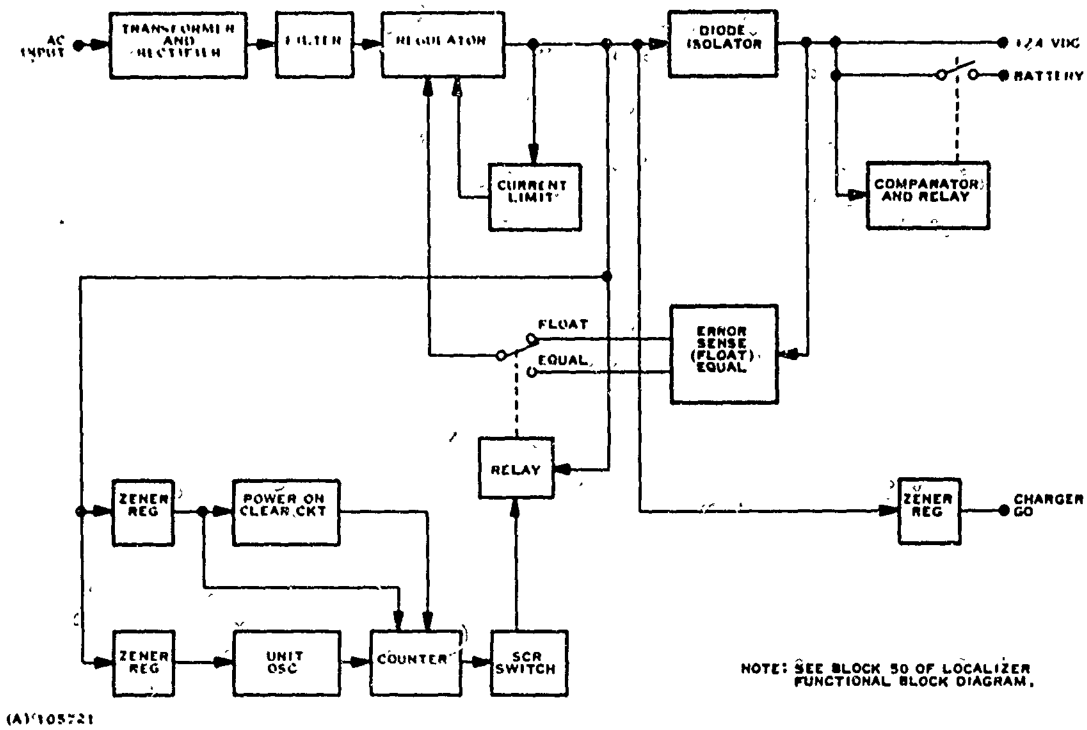


Figure A-17. Far Field Monitor Battery Charger

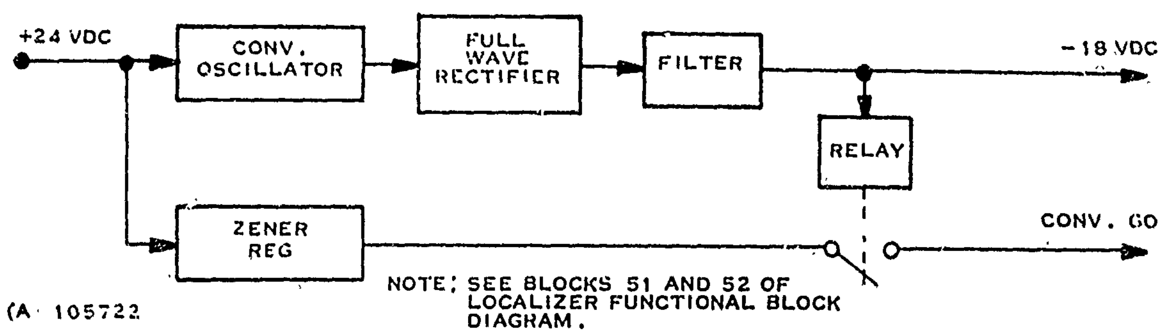


Figure A-18. Far Field Monitor Dc/Dc Converter

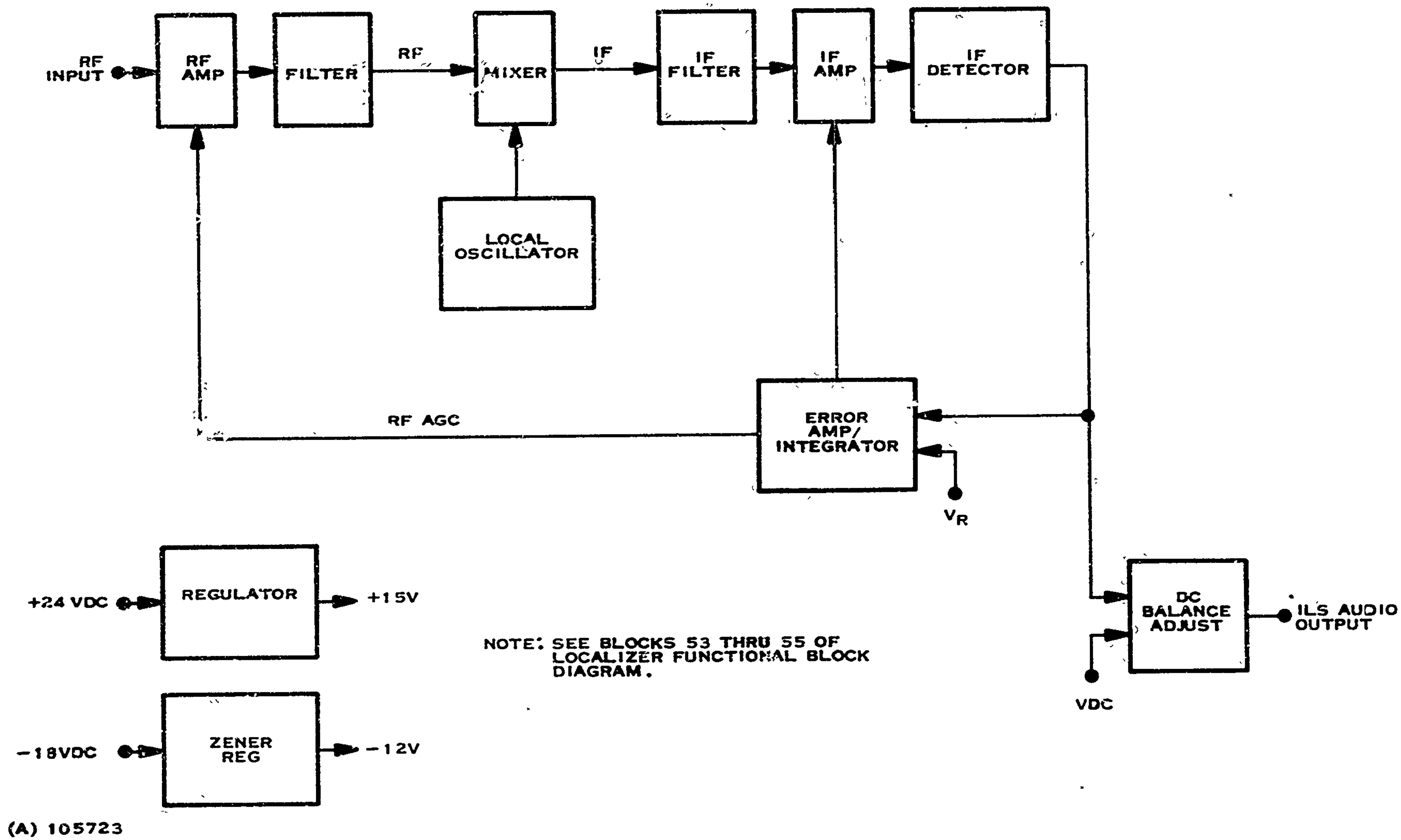


Figure A-19. VHF Receiver

Appendix B

Glideslope Detailed Functional Block Diagrams

Appendix B

Glideslope Detailed Functional Block Diagrams

This appendix consists of detailed functional block diagrams for the glideslope. Figures B-3 through B-13 cover the numbered blocks for figure B-1. Figure B-2 and the accompanying table B-1 detail the glideslope control unit.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2)

Name	Definition
A_{BAT}:	Alarm due to a drop in the main battery voltage.
A_{CONV}:	Alarm on one of the DC/DC converter voltages.
A_{MD}:	Misalignment detector alarm with inhibit.
$A_{PE_{RC}}$:	Power/environmental alarm sent to remote control.
A_S:	Alarm due to standby monitors.
$A_{S(D)}$:	Alarm due to standby monitors, delayed.
A_{SM}:	Alarm due to standby monitors, memorized.
AB:	Abnormal condition signal.
AB_{MON}:	Abnormal condition signal due to monitor channel alarm.
$AB_{MON_{RC}}$:	Monitor alarm sent to remote control.
AC:	AC power alarm from one of the two battery chargers.
BC:	Battery charger alarm from one of the two chargers.
BLINK:	Blinker output signal, a square wave oscillator.
C:	Cycling command signal for transmitters.
C_{ANT}:	Command to have transmitter no. 1 connected to the antenna.
$\overline{C}_{ANT}$:	Command to have transmitter no. 2 connected to the antenna.
C_1:	Command to turn on transmitter no. 1.
C_2:	Command to turn on transmitter no. 2.
CAT II_{RC}:	Signal to remote control used to determine Category II status.
CAT III_{RC}:	Signal to remote control used to determine Category III status.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2) (Continued)

Name	Definition
CONTROL:	Cycle command (MAIN, STBY, or OFF).
CL_{11}:	Category III DDM clearance alarm, monitor no. 1.
CL_{12}:	Category III DDM clearance alarm, monitor no. 2.
CL_{13}:	Category III DDM clearance alarm, monitor no. 3.
CL_{21}:	Category III SDM clearance alarm, monitor no. 1.
CL_{22}:	Category III SDM clearance alarm, monitor no. 2.
CL_{23}:	Category III SDM clearance alarm, monitor no. 3.
CL_{31}:	Category III RF clearance alarm, monitor no. 1.
CL_{32}:	Category III RF clearance alarm, monitor no. 2.
CL_{33}:	Category III RF clearance alarm, monitor no. 3.
CSE_{11}:	Category III DDM course alarm, monitor no. 1.
CSE_{12}:	Category III DDM course alarm, monitor no. 2.
CSE_{13}:	Category III DDM course alarm, monitor no. 3.
CSE_{21}:	Category III SDM course alarm, monitor no. 1.
CSE_{22}:	Category III SDM course alarm, monitor no. 2.
CSE_{23}:	Category III SDM course alarm, monitor no. 3.
CSE_{31}:	Category III RF course alarm, monitor no. 1.
CSE_{32}:	Category III RF course alarm, monitor no. 2.
CSE_{33}:	Category III RF course alarm, monitor no. 3.
CSE 111:	Category III DDM course alarm, monitor no. 1.
CSE 112:	Category III DDM course alarm, monitor no. 2.
CSE 113:	Category III DDM course alarm, monitor no. 3.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2) (Continued)

Name	Definition
I_C:	Inhibit signal to inhibit transmitter cycling capability.
I_{MAIN}:	Main inhibit to main monitor channels.
I_{ON}:	Inhibit signal due to power turn-on.
I_T:	Inhibit signal due to transfer commands either auto or manual.
I_S:	Inhibit signal due to shutdown commands, either auto or manual.
I_{STBY}:	Standby inhibit to standby monitor channels.
L_{AB}:	Abnormal status lamp signal.
L_{AC}:	AC power alarm status lamp signal.
L_{BAT}:	Battery alarm status lamp signal.
L_{BC}:	Battery charger alarm status lamp signal.
L_C:	DC/DC converter alarm status lamp signal.
$L_{MD\ A}$:	Misalignment detector alarm lamp.
$L_{MD\ BY}$:	Misalignment detector bypass lamp.
L_{MLB}:	Misalignment detector bypass lamp.
L_{MM}:	Monitor mismatch status lamp signal.
L_N:	Normal status lamp signal.
L_S:	Shutdown status lamp signal.
L_{TEMP}:	Temperature alarm status lamp signal.
L_{X1}:	Transmitter no. 1 connected to antenna status lamp signal.
L_{X2}:	Transmitter no. 2 connected to antenna status lamp signal.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2) (Continued)

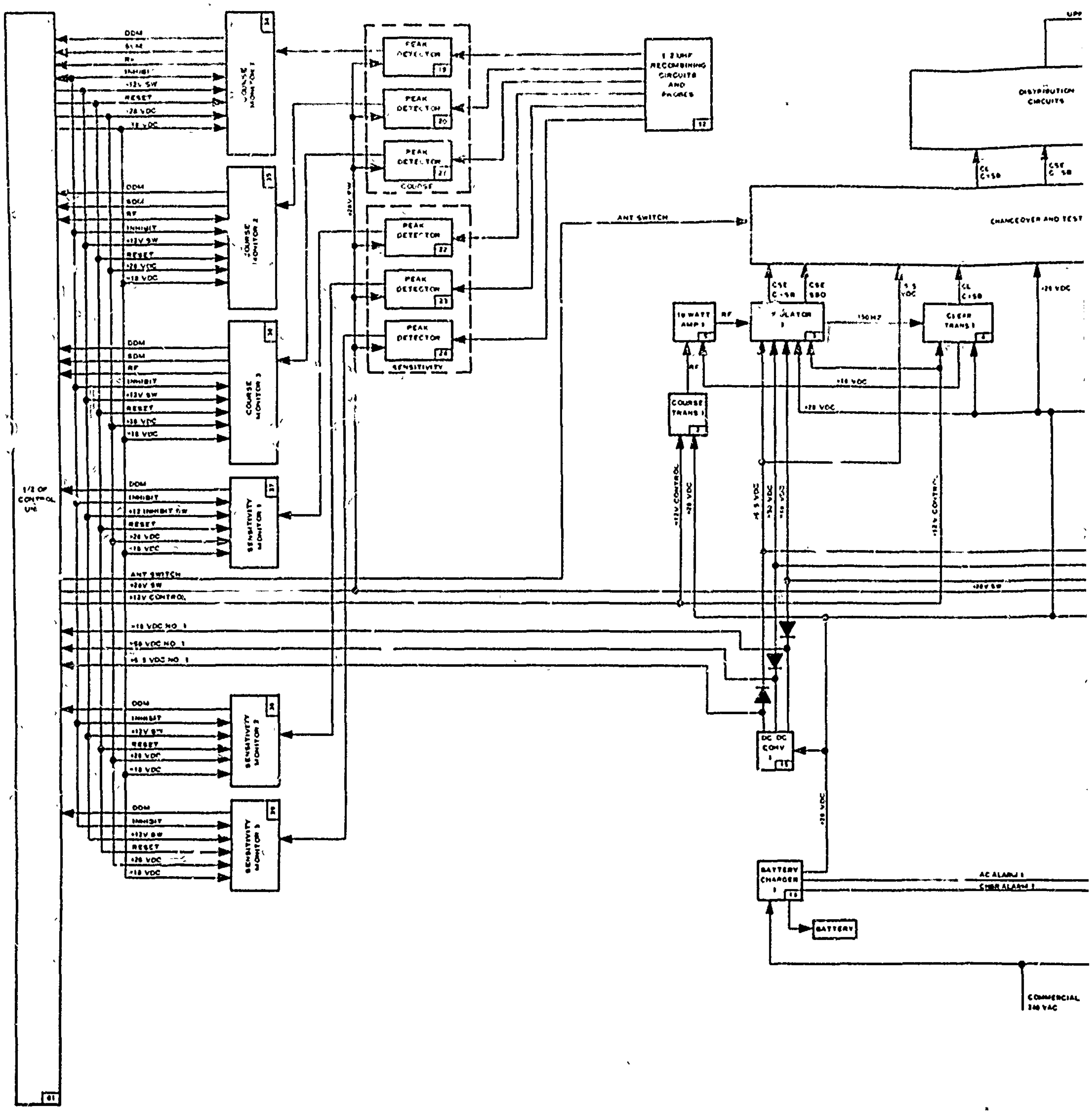
Name	Definition
LOC:	Local control of transmitting unit.
LT:	Transfer signal memorized.
MA_{CL}:	Clearance monitor alarm.
$MA_{CSE_{II}}$:	Course monitor alarm, Category II alarm limits.
$MA_{CSE_{III}}$:	Course monitor alarm, Category III alarm limits.
$MA_{NF(D)}$:	Near field monitor alarm which is delayed.
MA_S:	Shutdown command from monitor alarms.
MA_{SEN}:	Sensitivity monitor alarm.
MA_T:	Transfer command from monitor alarms.
MAIN:	Main transmitter "on" status signal.
$MAIN_{RC}$:	Signal to remote control used to determine MAIN status.
MD_A:	Misalignment detector alarm without inhibit.
MD_{BYL}:	Misalignment detector bypassed locally.
MLB:	Monitors locally bypassed.
MM_{CL}:	Clearance monitor mismatch.
$MM_{CL/NF}$:	Clearance or near field monitor mismatch.
$MM_{CSE_{III}}$:	Course monitor mismatch, Category III alarm limits.
$MM_{NF(D)}$:	Near field monitor mismatch which is delayed.
MM_{SEN}:	Sensitivity monitor mismatch, Category III alarm limits.
NF 1:	Category III DDM near field alarm, monitor no. 1.
NF 2:	Category III DDM near field alarm, monitor no. 2.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2) (Continued)

Name	Definition
NF 3:	Category III DDM near field alarm, monitor no. 3.
OFF:	Both transmitters "off" status signal.
OFF_{RC}:	Signal to remote control used to determine OFF status.
ON/OFF:	Front panel control unit power supply control.
REM:	Remote control of transmitting unit.
$\overline{RESET}$:	Signal to reset alarm memory latches.
S_{CL}:	Standby clearance monitor alarm - DDM, SDM, or RF with Category III limits.
S_{CSE}:	Standby course monitor alarm - DDM, SDM, or RF with Category III limits.
S_M:	Shutdown signal memorized.
S_{SEN}:	Standby sensitivity monitor alarm - DDM with Category III limits.
S_0:	Both transmitter are selected to be off.
S_1:	Transmitter no. 1 is selected as main.
S_2:	Transmitter no. 2 is selected as main.
$\overline{S}_{12}$:	Selection of transmitter no. 1 memorized.
S_{12}:	Selection of transmitter no. 2 memorized.
SEN_{11}:	Category III DDM sensitivity alarm, monitor no. 1.
SEN_{12}:	Category III DDM sensitivity alarm, monitor no. 2.
SEN_{13}:	Category III DDM sensitivity alarm, monitor no. 3.
STBY:	Standby transmitter "on" status signal.
$STBY_{RC}$:	Signal to remote control used to determine STANDBY status.
TEMP:	Temperature alarm inside main cabinet.

Table B-1. Definition of Signal Names (Glideslope Control Unit, Figure B-2) (Continued)

Name	Definition
XFR:	Transfer command due to XFR1 or XFR2 (redundant for remote recognition).
XFR1:	Transfer command due to course and sensitivity (redundant).
XFR2:	Transfer command due to clearance and near field (redundant).
+12V CONTROL:	Control signal to turn on monitor channels.
-18V:	A common -18v from the two DC/DC converters.
-18_1:	-18 volts from converter no. 1.
-18_2:	-18 volts from converter no. 2.
+28V BATT:	The voltage of the main batteries.
$+5_1$:	+5 volts from converter no. 1.
$+5_2$:	+5 volts from converter no. 2.
-50_1:	-50 volts from converter no. 1.
-50_2:	-50 volts from converter no. 2.



PEAK DETECTOR
COURSE
SENSITIVITY
COURSE MONITOR 2
COURSE MONITOR 3
SENSITIVITY MONITOR 1
SENSITIVITY MONITOR 2
SENSITIVITY MONITOR 3
1/2 OF CONTROL UNIT
DDM
SDM
RF
INHIBIT
RESET
+28 VDC
+18 VDC
ANT SWITCH
+28V SW
+12V CONTROL
DISTRIBUTION CIRCUITS
CHANGEOVER AND TEST
COURSE TRANS 1
CLEAR TRANS 1
DC DC CONV
BATTERY CHARGER
BATTERY
AC ALARM 1
CHGR ALARM 1
COMMERCIAL 240 VAC

(R)105723

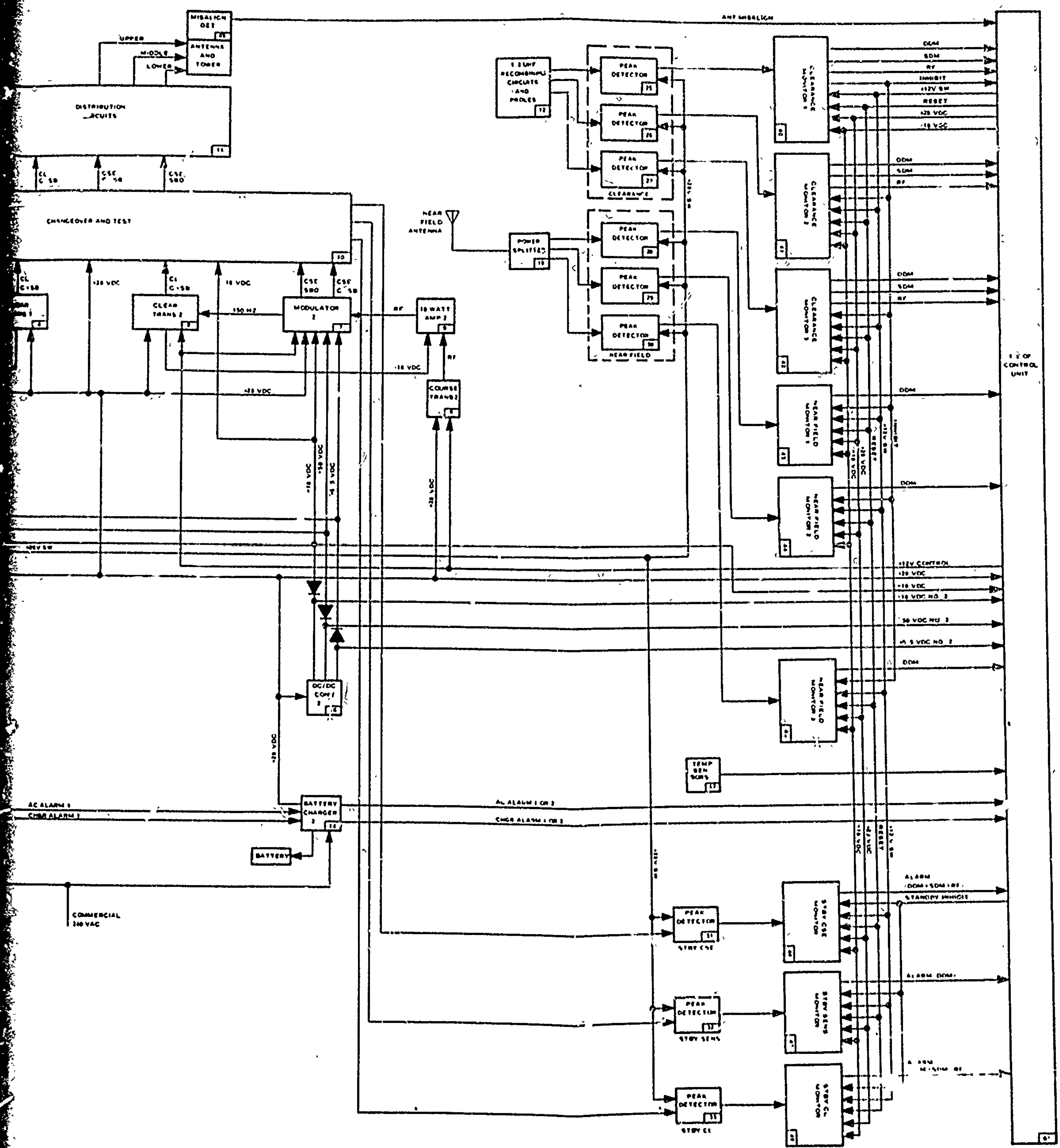
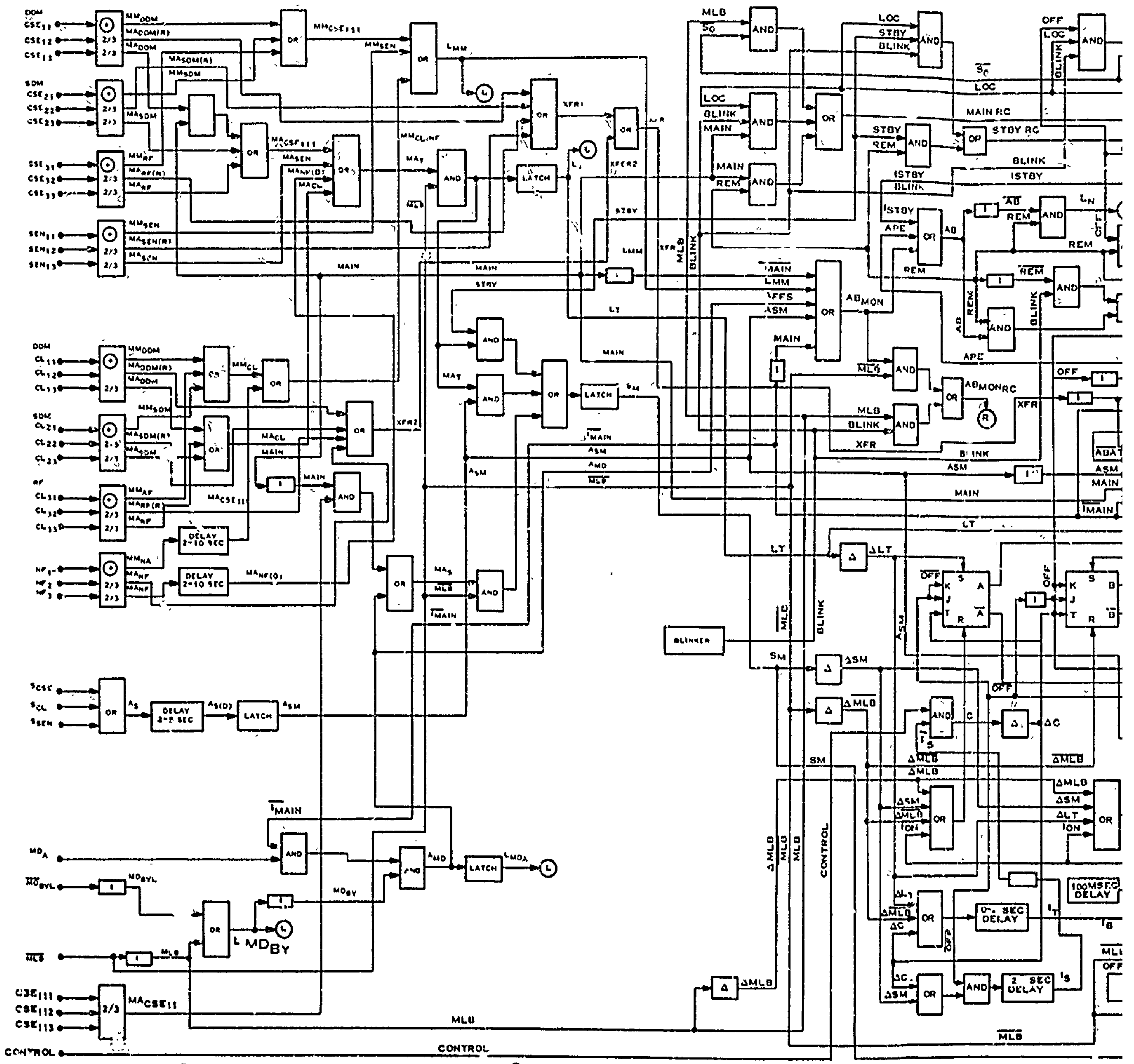


Figure B-1. Glideslope Station



Ⓛ → FRONT PANEL LAMP Ⓡ → SIGNAL TO REMOTE CONTROL Δ → DIFFERENTIATES LOGIC SIGNAL

(R)105725

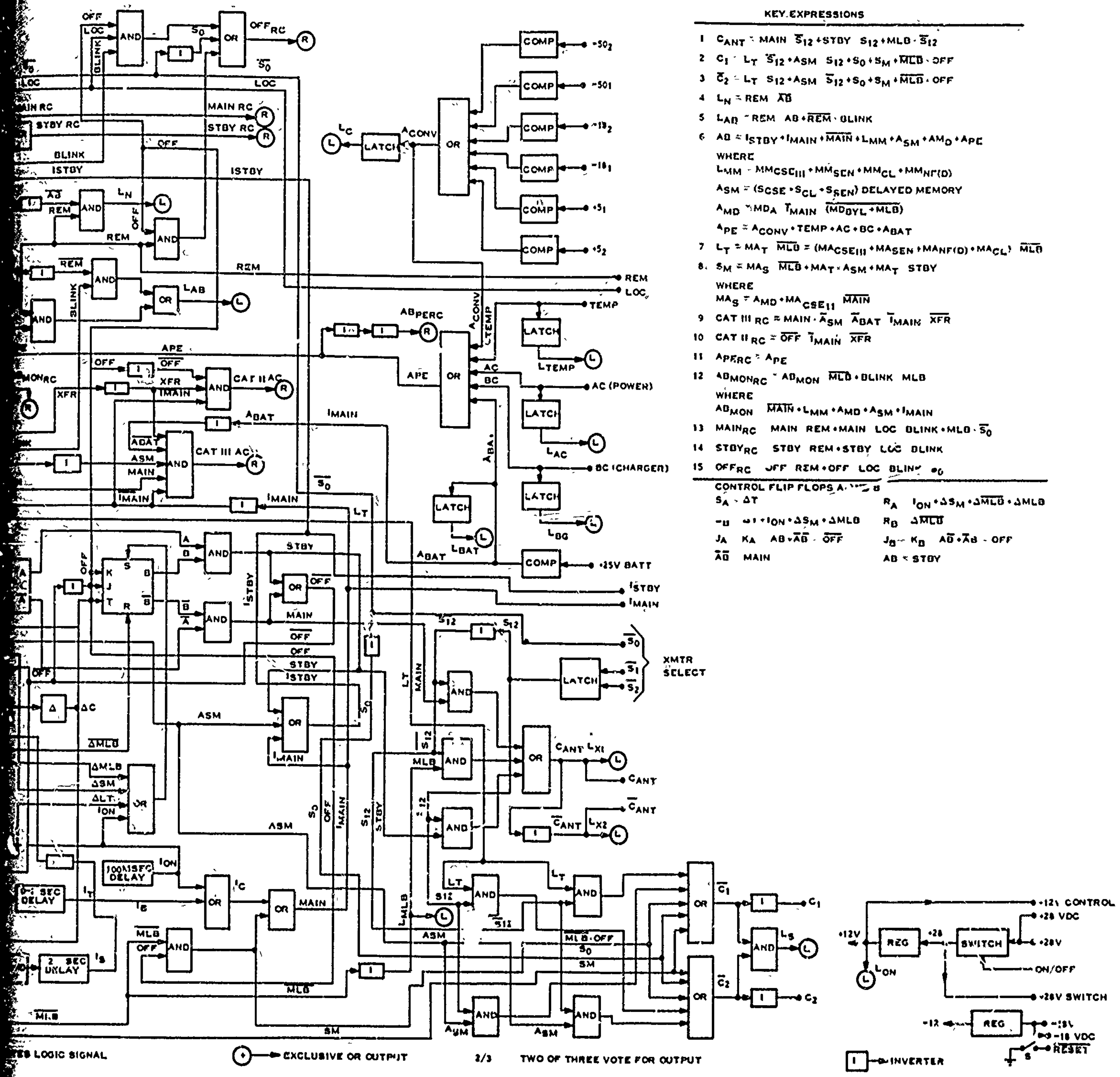
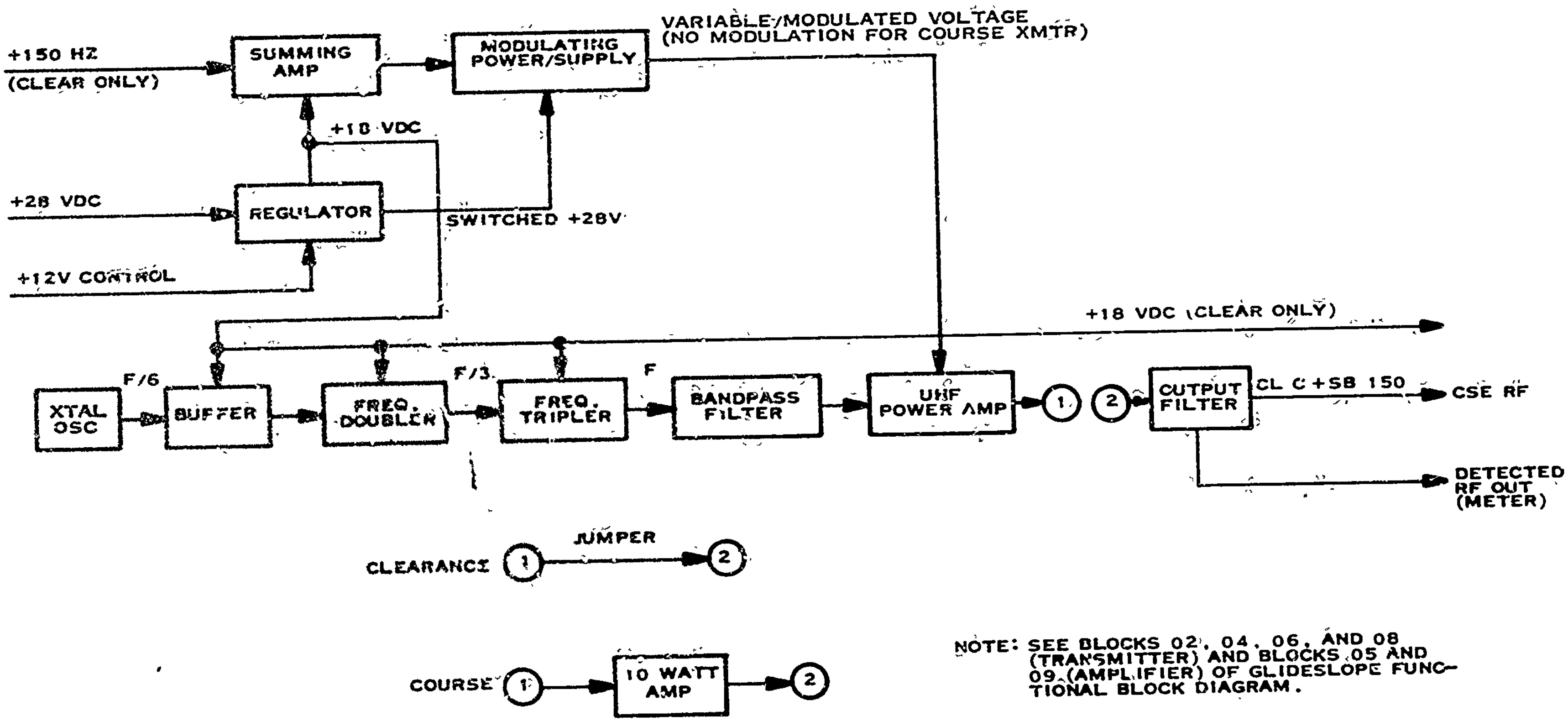
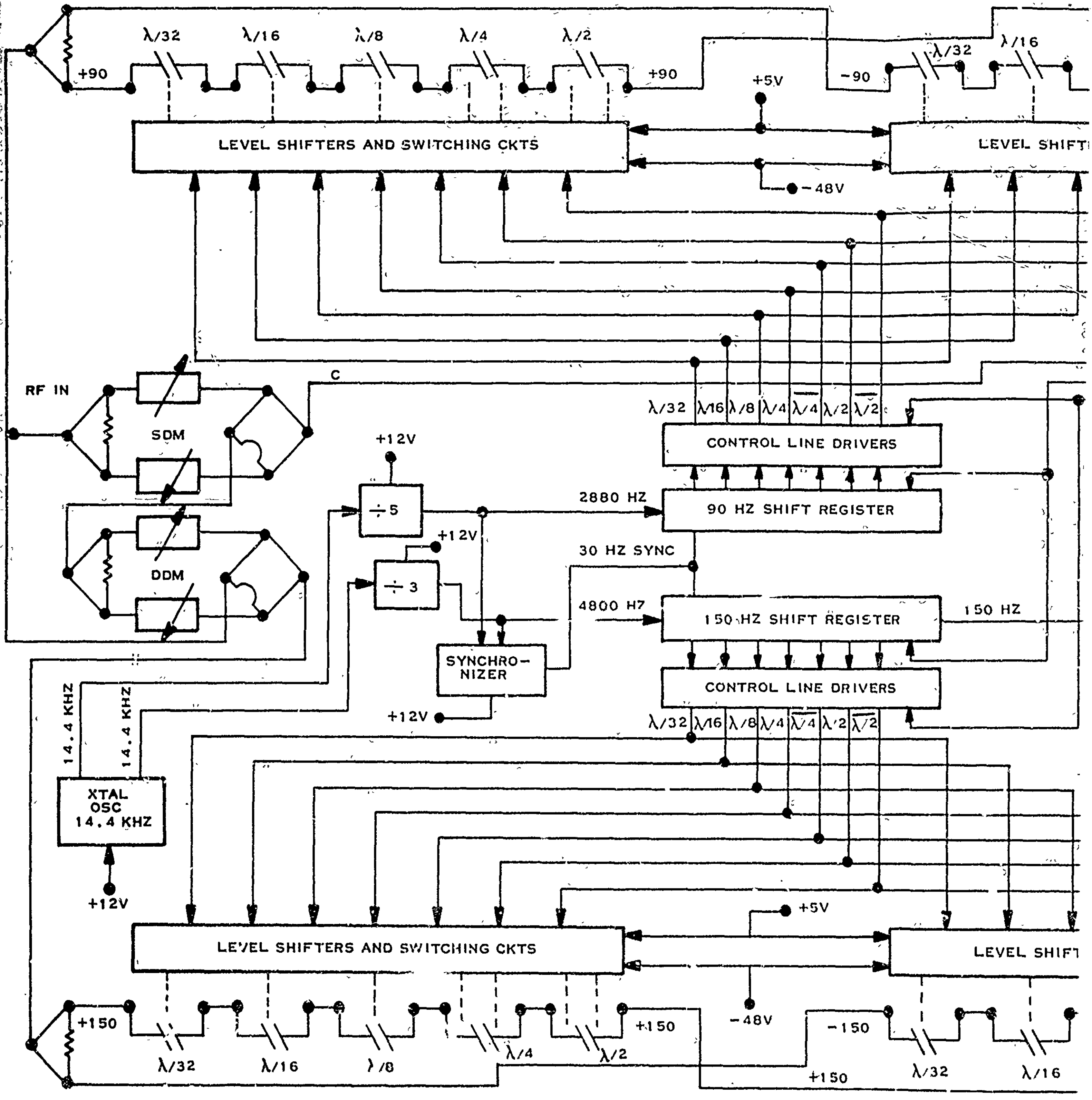


Figure B-2. Glideslope Control Unit



(A) 105726

Figure B-3. UHF Transmitter (Course and Clearance) and 10-Watt Amplifier



NOTE: SEE BLOCKS 03 AND 07 OF GLIDESLOPE FUNCTIONAL BLOCK DIAGRAM.

(B) 105727

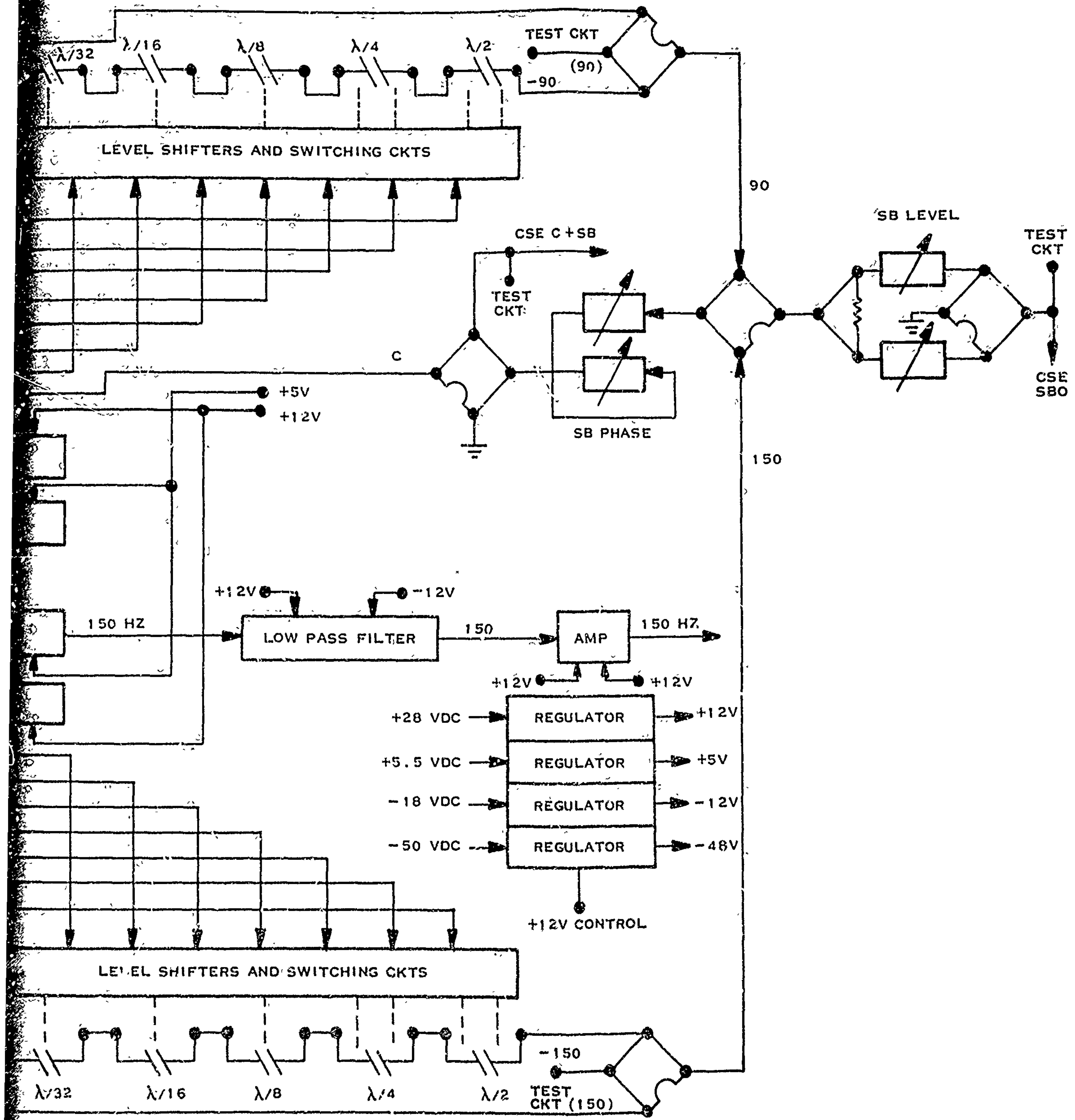


Figure B-4. UHF Modulator

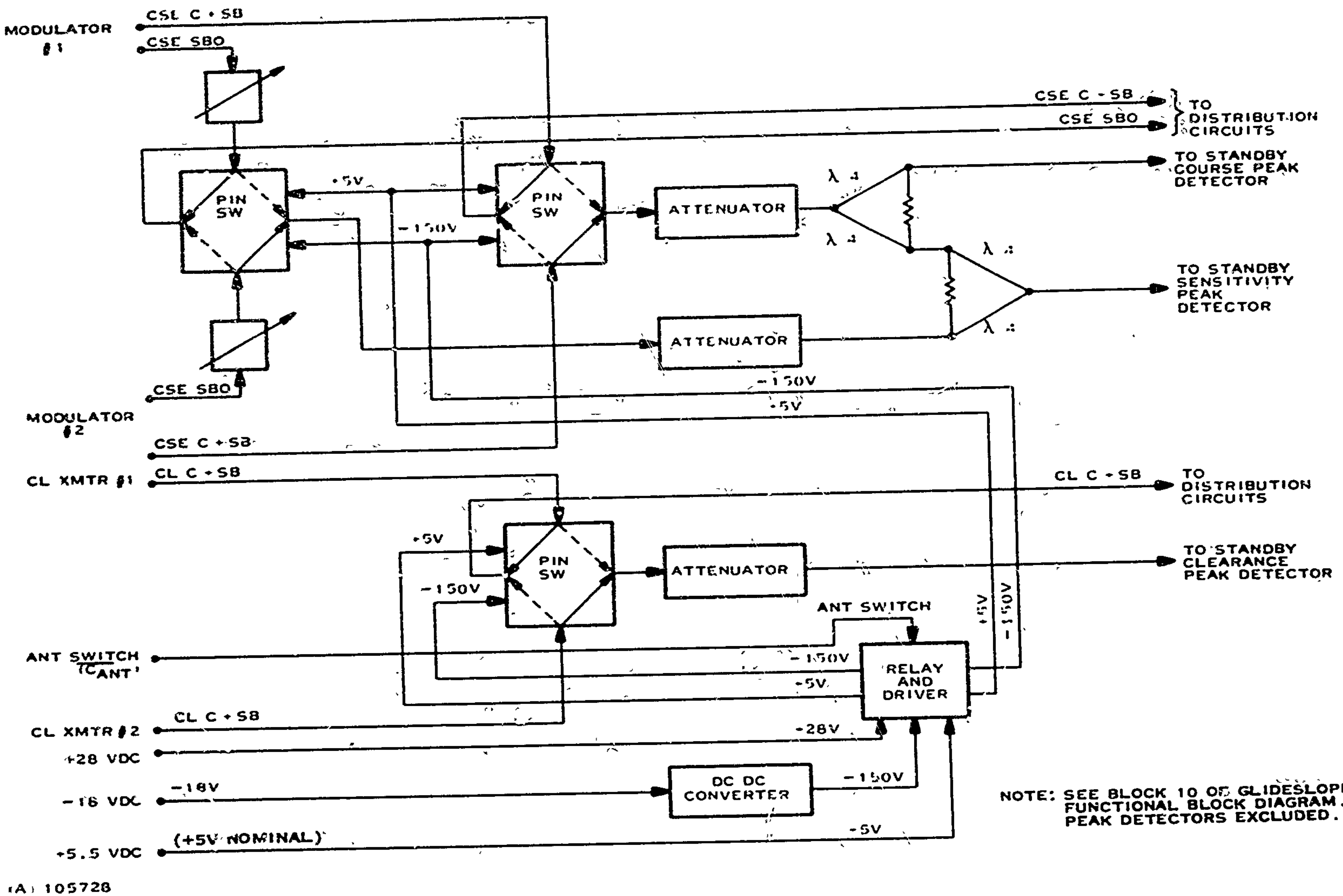
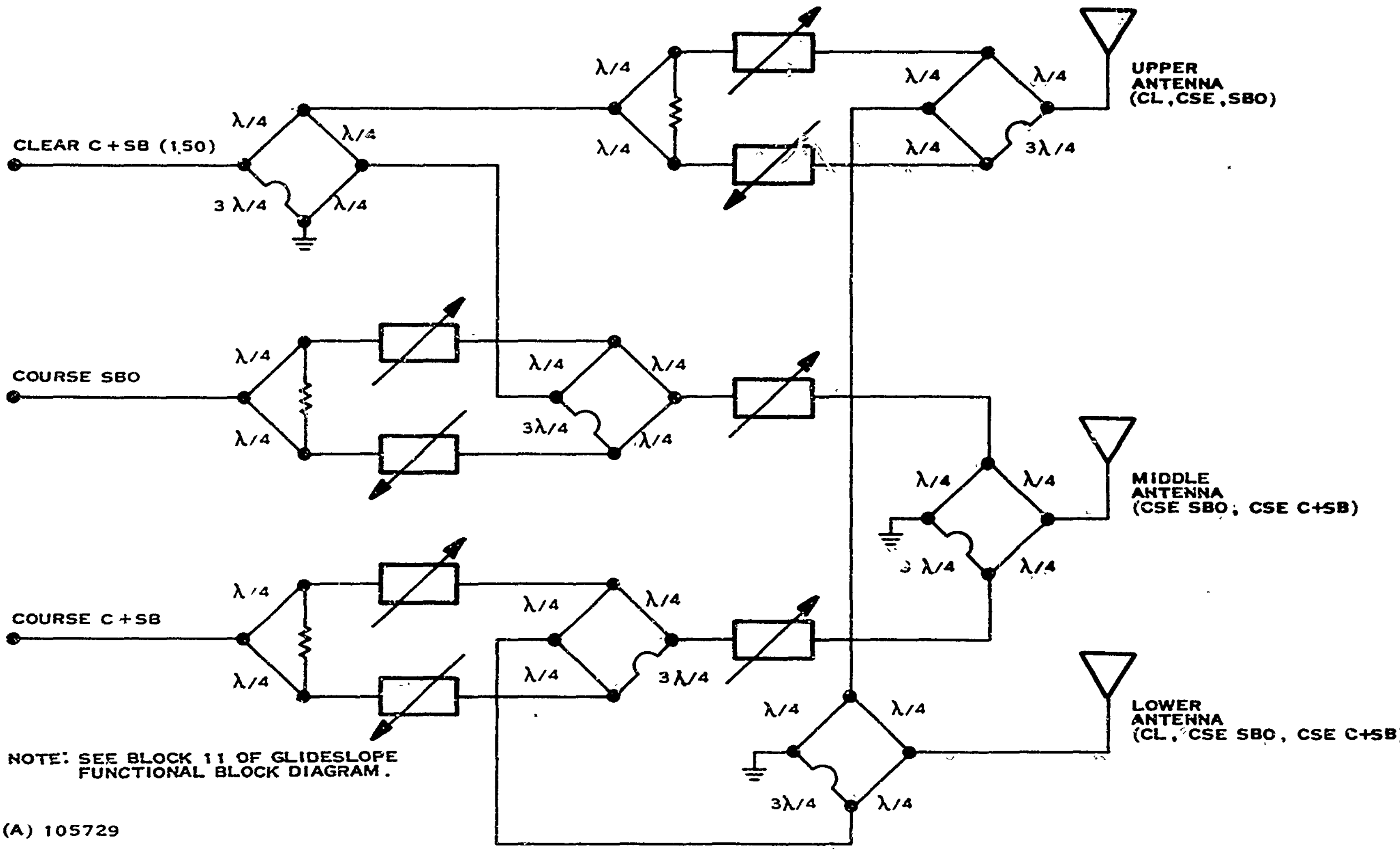


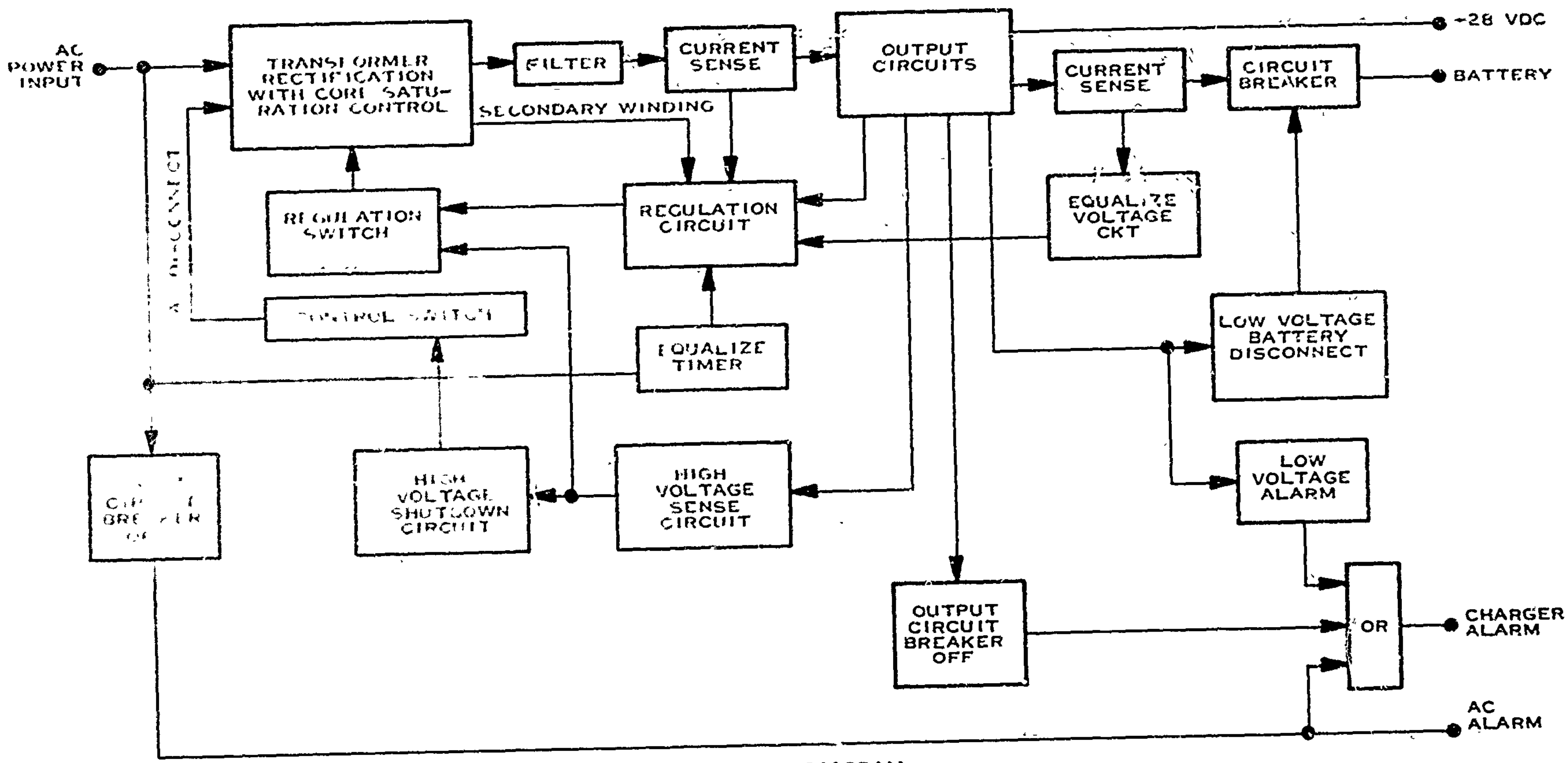
Figure B-5. UHF Changeover and Test Assembly



NOTE: SEE BLOCK 11 OF GLIDESLOPE FUNCTIONAL BLOCK DIAGRAM.

(A) 105729

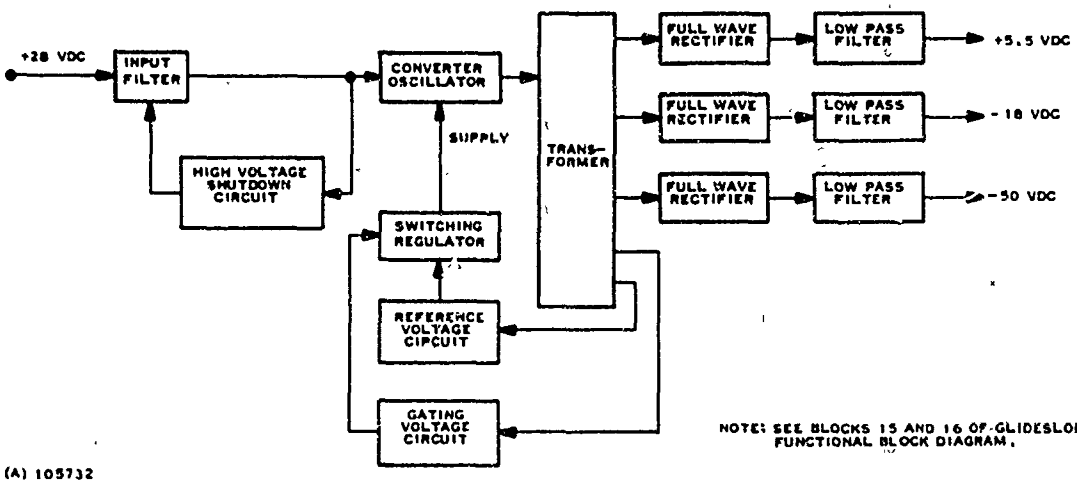
Figure B-6. UHF Distribution Circuits



NOTE: SEE BLOCKS 13 AND 14 OF GLIDESLOPE FUNCTIONAL BLOCK DIAGRAM.

"CHARGER ALARM" AND "AC ALARM" ARE OPEN RELAY CONTACTS IN THE ALARM STATE, CLOSED NORMALLY. THE CORRESPONDING ALARMS FROM BOTH CHARGERS ARE WIRED IN SERIES.

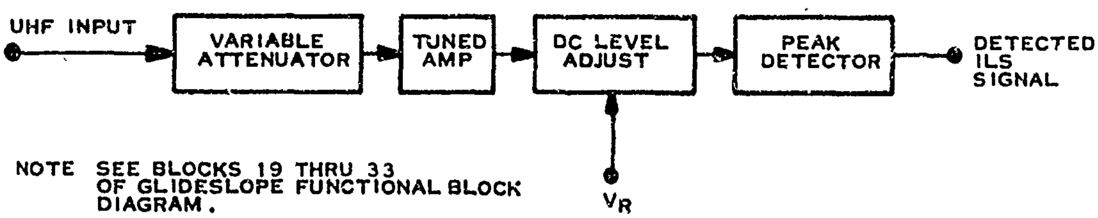
Figure B-9. Battery Charger



NOTE: SEE BLOCKS 15 AND 16 OF GLIDESLOPE FUNCTIONAL BLOCK DIAGRAM.

(A) 105732

Figure B-10. Dc/Dc Converter



NOTE SEE BLOCKS 19 THRU 33 OF GLIDESLOPE FUNCTIONAL BLOCK DIAGRAM.

(A) 105733

Figure B-11. UHF Peak Detectors

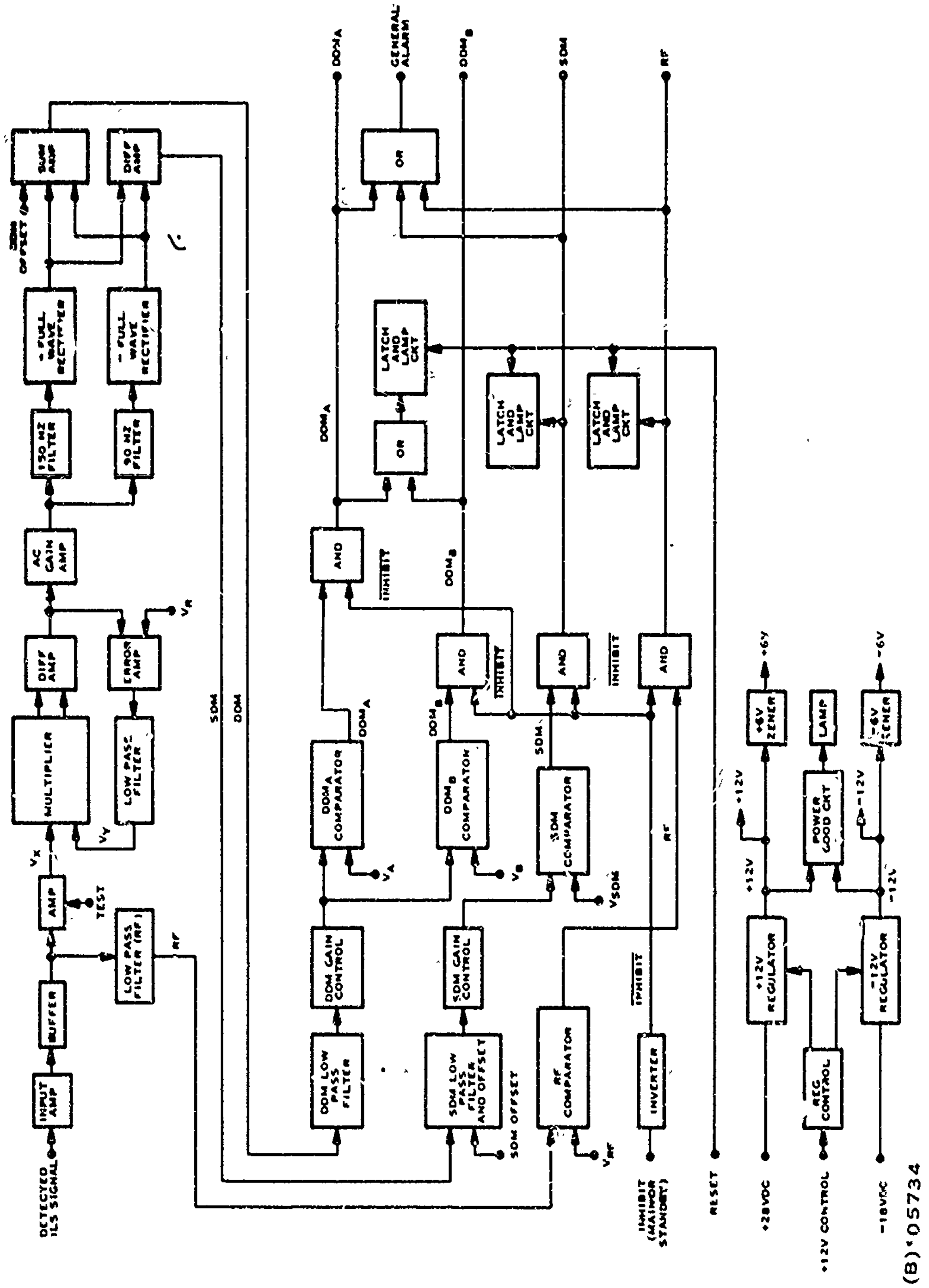


Figure B-12. Monitor Channel

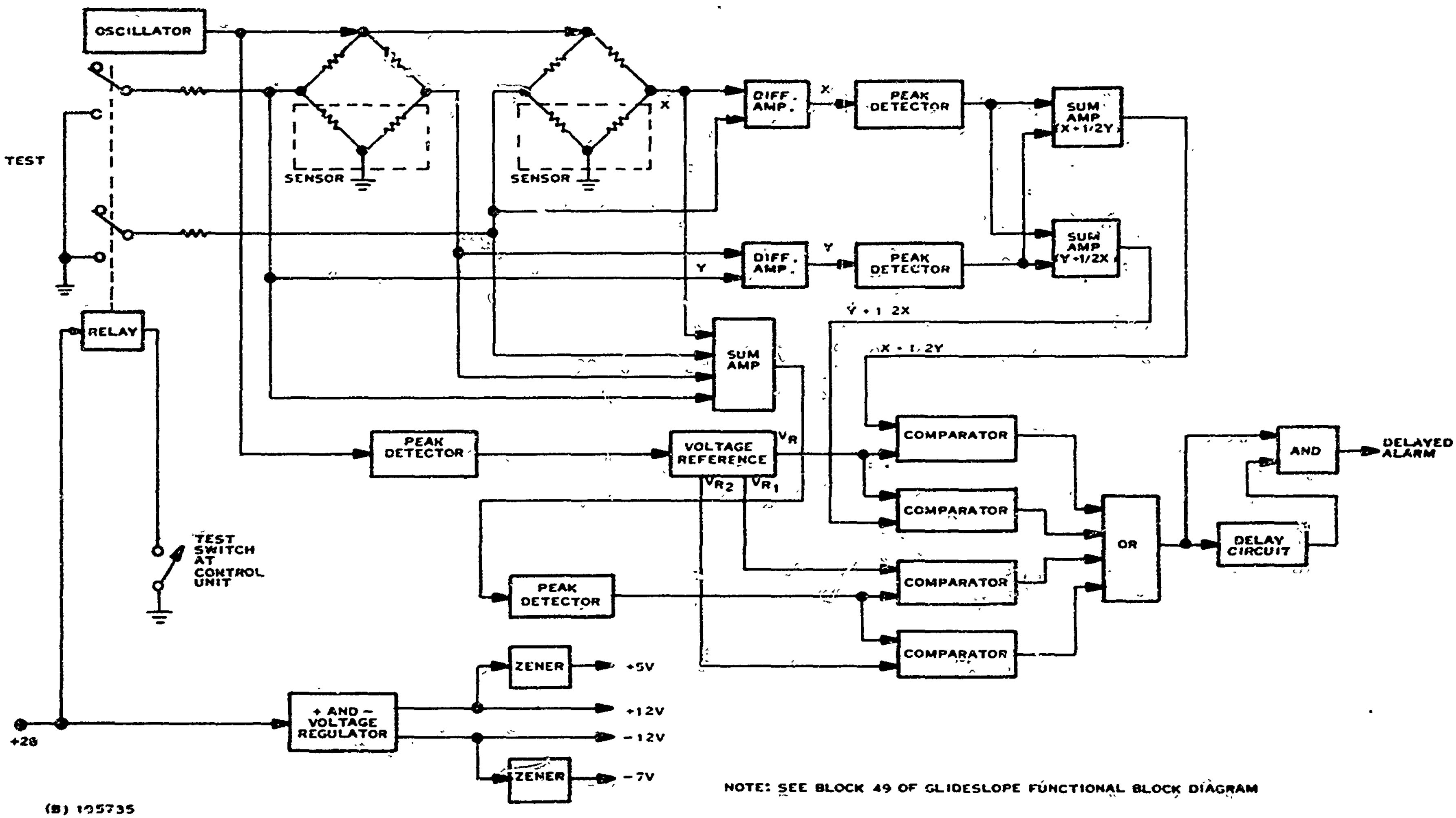


Figure B-13. Misalignment Detector

Appendix C

Localizer Failure Analysis

Appendix C

Localizer Failure Analysis

This appendix, referred to in section 7.0, consists fo the failure analysis for the localizer, as shown in table C-1.

Table C-1. Localizer Failure Analysis

System: SSILS
Subsystem: LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Course Transmitter MAIN or STANDBY	02 or 07 N	The course transmitter delivers a VHF carrier to the modulator. The carrier is also modulated in the transmitter by the 1020 Hz ID tone and also the low frequency warning signal when necessary.	Loss of all modulation.	Loss of ID radiation and warning signal capability.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	I.D. mon. alarms	1.446 λ_{NA} + λ_{2A} or λ_{7A}	"Transfer would not occur on failure of standby unit. Loss of Cat. III status would occur even though "main" is still operational.
			Loss of RF carrier.	Loss of course C-SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Course, sensitivity, and near field monitor alarms on main cabinet.	7.150 λ_{NB}	NOTE Although near field monitor lights are "on", their alarms are not processed. NOTE λ_N implies the failure rate of each separate item identified in the I.D. No. column.
Clearance Transmitter MAIN or STANDBY	4 or [illegible]	The clearance transmitter delivers a clearance C-SB to the antennas via clearance distribution [illegible]. In addition VHF carrier and [illegible] are fed directly to the sideband generator for the operation of clearance SBO signal.	Loss of all modulation.	Loss of sidebands on the C-SB signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on clearance monitors.	1.446 λ_{NA}	"Transfer" would not occur on failure of standby unit.
			Loss of RF carrier.	Loss of clearance C-SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on clearance monitors.	7.150 λ_{NB}	
Sideband Generator MAIN or STANDBY	05 or 10	Provides clearance SBO signal to the distribution circuits.	Loss of output signal.	Loss of clearance SBO signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on clearance monitors.	10.250 λ_N	"Transfer" would not occur on failure of standby unit.
Modulator MAIN or STANDBY	03 or 08	Provides course VHF carrier amplitude modulated by a 90 Hz and 150 Hz signal, CSE C-SB. It provides the course SBO signal. A LOW frequency 90-150 Hz signal which feeds the clearance transmitter, and a 90-150 Hz signal feeding the sideband generator.	Loss of low freq. oscillator (14.4 KHz) resulting in loss of all 90 Hz and 150 Hz modulation.	Loss of the following system signals: 1. SF 90-150 2. SB in clearance C-SB 3. LF 90-150 4. Clearance SBO 5. Course SBO 6. SB in course C-SB		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, near field, and clearance monitors – main/ [illegible]	2.413 λ_{NA}	"Transfer" would not occur on failure of standby unit. Loss of Cat. III status would occur even though "main" is still operational.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat-III	Cat II	Off	Remote Control	Control Unit	Other		
Modulator (Continued)	03 or 08		Loss of VHF carrier to digital phasing ckts (to either or both of the 90 and 150 phase shifters).	Loss of SB in course C+SB signal and course SBO signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANS-FER"	Alarms on all course, sensitivity, and near field monitors.	0.413 λ_{NB}	
			Loss of 90 or 150 dividers, synchronization circuitry or 90/150 Hz shift registers.	Out of tolerance course and clearance C+SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANS-FER"	Alarms on all course, sensitivity, near field and clearance monitors.	1.453 λ_{NC}	
			Loss of $\lambda/32$ driving signal to delay line (either the 90 Hz or 150 Hz phase shifter).	Slight distortion of the course C+SB and SBO signals.	X			NONE	NONE		2.426 λ_{ND}	Not hazardous - signal still within Cat. III tolerance.
			Loss of $\lambda/16$ driving signal to the delay lines (either the 90Hz or 150 Hz phase shifter).	Distortion somewhat more than $\lambda/32$ of the course C+SB and SBO signals.	X			NONE	NONE		2.426 λ_{NE}	Not hazardous - signal still within Cat. III tolerance.
			Loss of $\lambda/8$, $\lambda/4$, $\bar{\lambda}/4$, $\lambda/2$ or $\bar{\lambda}/2$ signal to the delay line. (either the 90 Hz or 150 Hz phase shifter).	Out of tolerance course C+SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANS-FER"	Alarms on all course, sensitivity, and near field monitors	12.832 λ_{NF}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Modulator (Continued)	03 or 08		Loss of +90, -90, +150, or -150 Hz phase shifter RF signal.	Out of tolerance course C+SB and SBO signals.		X		"MON ABN" and "STBY".	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, and near field monitors.	1.302 λ_{NG}	
			Loss of either the 90 Hz or 150 Hz sinusoidal signal for clearance transmission.	Out of tolerance clearance C+SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all clearance monitors.	1.552 λ_{NH}	
			Loss of 90+150 Hz signal.	Loss of modulation for clearance transmitter resulting in SB loss of clearance C+SB.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all clearance monitors.	0.388 λ_{NI}	
			Loss of 90-150 Hz signal.	Loss of clearance SBO signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all clearance monitors.	0.756 λ_{NJ}	
Course Monitor CHANNELS (1, 2, or 3) (MAIN)	35, 36, or 37	Provide monitoring of the course position (DDM), the % modulation (SDM), and the course RF power level.	Loss of monitoring ability, producing alarms.	Loss of 2 of 3 monitor voting capability. Now dependent on 1 of 2 remaining monitors for system control (transmitter transfer capability).	X			"MON ABN" and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective monitor channel.	13.310 λ_{NA}	If another corresponding monitor alarm failure occurred in one of the remaining two monitors, immediate localizer shutdown will result.
			Loss of monitoring ability, producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		5.390 λ_{NB}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Course Monitor Channel (STANDBY)	46	Same as main course monitor channels except monitors course parameters of standby unit.	Loss of monitoring ability, producing alarms.	Shutdown of standby transmitter		X		"MON ABN" and "MAIN"	"ABN"	Alarm light(s) on standby course monitor.	13.310 λ_{46A}	
			Loss of monitoring ability, producing no alarms.	Loss of standby course monitoring.	X			NONE	NONE		5.390 λ_{46B}	
Sensitivity Monitor CHANNELS 1, 2 or 3 (MAIN)	38, 39, or 40	Provide monitoring of the course width (DDM).	Loss of monitoring ability producing alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system control.	X			"MON ABN" and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective monitor channel.	9.367 λ_{NA}	If another corresponding monitor DDM failure occurred in one of the remaining two monitors, immediate localizer shutdown will result.
			Loss of monitoring ability producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		2.892 λ_{NB}	Only DDM monitoring circuitry is critical.
Standby Sensitivity Monitor Channel	47	Provide monitoring of the standby course width (DDM).	Loss of monitoring ability producing alarms.	Shutdown of the standby transmitter.		X		"MON ABN" and "MAIN"	"ABN"	Alarm light(s) on standby sensitivity monitor.	9.367 λ_{47A}	Only DDM monitoring circuitry is critical.
			Loss of monitoring ability producing no alarms	Loss of standby course monitoring.	X			NONE	NONE		2.892 λ_{47B}	
Near Field Monitor CHANNELS 1 or 2	41 or 42	Provide monitoring of the near field course position (DDM).	Loss of monitoring ability producing alarms.	Loss of 2 of 2 monitor capability. Now dependent upon remaining monitor for system control.	X			"MON ABN" and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective near field monitor.	11.099 λ_{NA}	SDM and DDM are strapped to provide one general alarm output.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate (λ x 10^6)	Remarks
Near Field Monitor CHANNELS (Continued)	41 or 42		Loss of monitoring ability producing no alarms.	Loss of near field monitoring.	X			NONE	NONE		3.822 λ_{NB}	Non-hazardous - near field monitoring considered not essential for Cat III operation.
Clearance Monitor CHANNELS No. 1, 2 or 3 (MAIN)	43, 44 or 45	Provide monitoring of the clearance DDM, modulation and clearance RF power level	Loss of monitoring ability producing alarm.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system control.	X			"MON ABN" and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective clearance monitor.	14.280 λ_{NA}	If another corresponding monitor alarm failure occurred in one of the remaining two monitors, immediate localizer shutdown will result.
			Loss of monitoring ability producing no alarm.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		5.551 λ_{NB}	
Clearance Monitor Channel (STANDBY)	4[illegible]	Same as main clearance monitor channels except monitors clearance parameters of standby unit.	Loss of monitoring ability producing alarm.	Shutdown of standby transmitter.		X		"MON ABN" and "MAIN"	"ABN"	Alarm light(s) on standby clearance monitor.	14.280 λ_{48A}	
			Loss of monitoring ability producing no alarm.	Loss of standby clearance monitoring.	X			NONE	NONE		5.551 λ_{48B}	
I.D. Unit (MAIN or STANDBY)	[illegible] or 11	Provides a keyed 1020 Hz audio signal (ID TONE) to aircraft for runway and approach identification.	Loss of ID signal (audio).	Transfer to standby unit.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on ID monitors.	3.949 λ_{NA}	"Transfer" would not occur on failure of standby unit. Loss of Cat. III status would occur even though "MAIN" is still operational.
			Loss of code or keying.	Transfer to standby unit.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on I. D. monitors.	13.134 λ_{NB}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^{-6}$)	Remarks
Control Unit	01	The control unit processes alarms received from the monitor channels, providing signals to shutdown the standby transmitter, to transfer main to standby, to shutdown both transmitters, or to indicate a monitor mismatch. In addition, the control unit generates inhibit signals, displays both locally and remotely transmitter and category status, and displays various power/temperature alarm conditions for both the main shelter and far field monitor operational features, such as bypass of monitors, main unit select, memorization of alarms are also associated with the control unit.	Generation of an erroneous transfer signal, due to alarm processing circuitry.	Causes both the main and the standby transmitter to shutdown immediately after the transfer.			X	"MON ABN" and "OFF"	"TRANSFER," "SHUTDOWN" and "ABNORMAL"	The FFM processes the "no signal" condition.	1.827 λ_{1A}	After a nominal 70 second delay, the "Far Field GO" light will go "off" and the "FF SHUTDOWN" light will come "on" at the control unit.
			Generation of an erroneous shutdown signal due to alarm processing circuitry.	Causes both the main and the standby transmitter to shutdown immediately.			X	"MON ABN" and "OFF"	"SHUTDOWN" and "ABNORMAL"	The FFM processes the "no signal" condition.	3.507 λ_{1B}	
			Generation of an erroneous mismatch signal.	Mismatch conditions do not effect category performance; however, failure of input gates may be hazardous.	X			"MON ABN" and "MAIN"	"MISMATCH" and "ABNORMAL"	No mismatch on monitor channels.	2.888 (λ_{1C1} = 0.42) (λ_{1C2} = 0.14) (λ_{1C3} = 0.14) (λ_{1C4} = 0.42)	Only input gating circuitry may be hazardous. (Effects monitoring circuitry).
			Inability to process a transfer signal from the integral course sensitivity, I.D., and/or clearance monitors.	Cat III parameter monitoring of the integral course, sensitivity, I.D., and/or clearance is virtually rendered useless.	X			(NONE)	(NONE)		3.470 λ_{1D1} = 1.249 (redund) λ_{1D1} = 0.140 (gate) λ_{1D2} = 0.700 (logic)	Redundancy has been incorporated so that performance downgrade is achieved in the event of a "True Cat III Alarm condition." NOTE Loss of I.D. monitoring is not hazardous.
			Inability to process a shutdown signal, initiated by the NF, FF, and/or Cat III course DDM.	Results in a loss of near field and/or far field Cat II monitoring capability.	X			(NONE)	(NONE)		2.256 λ_{1E}	Not hazardous - Cat III integral and far field monitoring still effective.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^{-6}$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (Continued)	01		Inability to process a shutdown signal, initiated by either a double transfer or the NF, FF, or Cat II course general alarm.	System will continue to radiate a signal (possibly faulty) during a shutdown status-only Cat II performance effected.	X			(NONE)	(NONE)		0.560 λ_{1F}	Not hazardous - Cat III performance and monitoring is uneffected.
			Inability to process a mismatch condition of any or all monitor sets.	No serious effects on system operation. Monitor mismatches may not be recognized but parameter "out of tolerance" conditions are still processed normally.	X			(NONE)	(NONE)		3.746 λ_{1G}	Not hazardous - mismatch conditions do not effect Cat III performance.
			Inability to process a standby alarm.	Standby unit monitoring is rendered useless.	X			(NONE)	(NONE)		1.359 λ_{1H}	If a standby transmitter failure also occurs, immediate shutdown upon transfer will result.
			Generation of an erroneous standby alarm.	Causes the standby transmitter to shutdown. Main continues to operate in Cat II status.		X		"MON ABN" and "MAIN"	"ABNORMAL"	No alarms on stby. monitor).	1.164 λ_{1I}	
			Inability to process any or all power/environmental alarms.	Loss of remote recognition of respective alarm conditions; loss of downgrade capability due to power/environmental alarms.	X			(NONE)	(NONE)		2.567 λ_{1J}	Not hazardous - power/environmental alarms merely downgrade performance after a time delay yet both transmitters are still available.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (Continued)	01		Generation of an erroneous battery alarm.	No effect other than erroneously downgrading the system to Cat II status.		X		"POW/ENVIR ABN" and "MAIN"	"ABNORMAL" and "BATT FAIL"		0.415 λ_{1K}	No hazardous --system still has the ability to operate on both transmitting units.
			Generation of any erroneous power/environmental alarm except a battery alarm.	No effect other than an erroneous abnormal indication.	X	Downgrade to Cat II after time delay.		"POW/ENVIR ABN" and "MAIN"	"ABNORMAL" and possibly the respective power or temperature alarm light.		2.029 λ_{1L}	Not hazardous
			Generation of an erroneous control signal that shuts down the main transmitting unit.	After the main transmitter shuts down, the loss of radiation is detected by the monitor channels and transfer is initiated to the standby unit.		X		"MON ABN" and "STBY"	"TRANSFER" and "ABN"	Alarms on some monitor channels.	0.420 λ_{1M}	Monitor channel alarm lights are unpredictable due to a race condition between the generated inhibit signal and the "no signal" input alarm processing.
			Generation of an erroneous control signal that shut down the standby transmitting unit.	After the standby transmitter shuts down, the loss of input signals to the standby monitor channels creates standby alarm conditions which are processed normally in the control unit.		X		"MON ABN" and MAIN"	"ABN"	Alarms on some standby monitor channels.	0.280 λ_{1N}	This failure mode is not generated by monitoring circuitry; hence, it may occur after a transfer to standby has occurred.
			Generation of an erroneous control signal that shuts down both transmitting units.	After a total shutdown is initiated, the loss of input signals to all monitor channels results in both a simultaneous processing of a transfer and shutdown condition in the control unit.			X	"MON ABN" and "OFF"	"TRANSFER", "SHUT-DOWN", and "ABN"	Alarms on some monitor channels.	0.140 λ_{1O}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Control Unit (Continued)	01		Inability to shutdown either the main or the standby transmitting unit.	No failure effect or indication until another failure occurred in the main or standby unit. At that time all control signals would be processed normally, except the respective transmitting unit would not cease transmission.	X			(NONE)	(NONE)		1.782 λ_{1P}	Not hazardous - performance category downgrade still possible. Note also that transfer capability still exists, hence, Cat III performance is not effected.
			Inability to effect a change of units feeding the antennas.	No failure effect or indication until a transfer command is received (due to some other failure). At that time all radiation will cease.	X			(NONE)	(NONE)		0.844 λ_{1Q}	Essentially renders the standby transmitter useless.
			Pre-mature change of units feeding the antennas.	If in MAIN, a transfer to STANDBY will occur, if in STANDBY, a transfer to OFF will occur. This is due to a momentary loss of signal.		X (assuming initial MAIN status)		"MON ABN" and "STBY"	"TRANSFER" and "ABN"	Alarms on some monitor channels.	0.960 λ_{1R}	Essentially renders either the main or standby transmitter useless.
			Generation of a continuous main and/or standby inhibit to the monitor channels.	The respective main and/or standby monitor channels are inhibited and, hence, rendered totally useless. Although the inhibit does not effect the far field monitor channels from alarming, the main inhibit does prevent the alarm from being processed in the control unit			X	"MON ABN" and "MAIN"	"ABNORMAL"		2.514 λ_{1S} λ_{1S1} = 0.198 (stby inhibit) λ_{1S2} = 2.316 (main inhibit)	Upon the generation of a continuous main inhibit, design modifications have been incorporated to take away Cat III and Cat II status. Although both transmitters may still be "GOOD", all monitoring is lost. λ_{1S1} is similar to λ_{1H}.

Table C-1. Localizer Failure Analysis (Cont'd)

System SCILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (Continued)	01		Inability to process a main inhibit to the monitor channels.	If another failure occurs which initiates a transfer, an immediate shutdown will occur since the monitors are not inhibited during the transition period.	X			(NONE)	(NONE)		2.658 λ_{1T}	Failure mode virtually renders the standby transmitter useless.
			Inability to process a standby inhibit to the standby monitor channels.	No effect on system operation - merely produce alarms on all standby monitor channels after a transfer has already occurred due to another failure.	X			(NONE)	(NONE)		0.370 λ_{1U}	Not hazardous - standby monitoring is meaningless after a transfer.
			Generation of an erroneous monitors locally bypassed signal.	The control unit cannot process transfer and shutdown command signals and, hence, the entire monitoring is rendered useless.			X	"ABNORMAL" flashing and "MAIN"	"MON LOC BYPASS" and "NORMAL"		0.140 λ_{1W}	Cat III and Cat II status taken away although both transmitters are still operational.
			Generation of an erroneous shutdown alert signal.	No effect on system operation - only causes the transmission of a false shutdown warning signal.	X			(NONE)	(NONE)		2.[illegible]52 λ_{1X}	Not hazardous - only psychological implications.
			Inability to generate a correct shutdown alert signal.	System may shut down instantaneously without any warning to pilot.	X			(NONE)	(NONE)		2.693 λ_{1Y}	Not hazardous - shutdown warning not vital to system operation.

Table C-1. Localizer Failure Analysis (Cont'd)

System: SSILS
Subsystem: LOCALIZER STATION

Identification: Item Name	Identification: (Fig. No.)	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Control Unit (Continued)	61		Loss of +12 volts in control unit power supply	All delay circuits produce an alarm output both a continuous main and standby inhibit are generated. An immediate shutdown will result due to the near field delay circuits			X	"MON ABN" and "OFF"	"ABN" and "SHUT-DOWN"	No alarms present on main cabinet due to inhibit.	0.339 λ_{1Z}	
			Loss of +12 volts in control unit power supply. (Note loss of switched 28v relays included)	All control logic is rendered useless. Both transmitters shutdown monitors channels, however, are inhibited and, hence, do not alarm.			X	"POW/ENVIR ABN" and "OFF"	All front panel lights off.	FFM processes the "no signal" condition.	1.506 λ_{1AA}	
			Loss of 1020 signal (1020 Hz) for either the main or standby unit.	Transfer to standby unit.		X		"MON ABN" and "STBY"	"ABN" and "TRANS-FER"	Alarms on I.D monitor.	0.676 λ_{1BB} λ_{1BB1} = 0.338 (main) λ_{1BB2} = 0.338 (stby)	"TRANSFER" would not occur on failure for standby unit. Loss of Cat III status would occur even though "main" is still operational.
Near Field Peak Detector No. 1 or No. 2	2 or 3	Each of the near field peak detectors receives its input signal from a near field antenna. The received RF signal is representative of the course alignment. Each peak detector then converts the RF signal into a low frequency signal, both DC and AC. The DC is representative of the course RF power the AC is the demodulated 90/150 Hz course signals.	Total loss of output signal (both AC and DC)	Loss of the input signal to the corresponding near field monitor channel, causing a monitor mismatch. Dependence upon remaining peak detector/monitor for near field monitoring. Now dependent upon 1 of 1 near field parameter monitor for system control. Shutdown	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF and SDM lights "on" on the corresponding near field monitor channel.	0.789 λ_{NA}	Near field monitoring only monitors Cat II course limits. The strap option for SDM alarms will be employed to detect "NO SIGNAL" input conditions.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda x 10^6$)	Remarks
Near Field Peak Detector (continued)	29 or 30			will result if remaining peak detector/monitor also fails.								
			Incorrect (low) DC output signal.	The corresponding monitor channel processes the failure as being a drop in course RF power and an increase in modulation percentage. Now dependent upon 1 of 1 for near field monitoring.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF and SDM lights "on" on the corresponding near field monitor channel.	0.386 λ_{NB}	
Course Peak Detectors No. 1, No. 2, or No. 3 (MAIN)	20, 21, or 22	Each of the course peak detectors receives a simulated course position input signal. This input signal is obtained by a combination of signals obtained by proximity probes at the radiating antennas. Each peak detector then converts the RF signal into a low frequency signal, both DC and AC. The DC is representative of the RF power; the AC is the demodulated 90/150/1020 Hz signal.	Total loss of output signal (both AC and DC).	Loss of input signal to corresponding monitor, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for integral course position and I.D. monitoring. Now dependent upon 1 of 2 course parameter monitors for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF and SDM lights "ON" on corresponding course monitor channel and an alarm on corresponding I.D. monitor.	0.789 λ_{NA}	Note that although both the remaining two peak detectors/monitors monitor integral course position, only an alarm on one of them is required to initiate a transfer.
			Incorrect (low) DC output signal.	The corresponding monitor channel processes the failure as being a drop in course RF power and an increase in modulation percentage. Now dependent upon 1 of 2 for integral course position monitoring.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF and SDM lights "ON" on corresponding course monitor channel.	0.386 λ [illegible]	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Sensitivity Peak Detectors No. 1, No. 2, or No. 3 (MAIN)	23, 24, or 25	Each of the sensitivity peak detectors receives a simulated input signal, representative of the course width (displacement sensitivity). This input signal is obtained by a combination of signals obtained by proximity probes at the radiating antennas. Each peak detector converts the RF signal into a low frequency signal both DC and AC. The DC is representative of the RF power, the AC is the demodulated 90/150 Hz signal.	Total loss of output signal (both AC and DC).	Loss of input signal to corresponding sensitivity monitor channel, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for integral course width monitoring. Now dependent upon 1 of 2 monitoring for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "ON" on corresponding sensitivity monitor channel.	0.789 λ_{NA}	Although the remaining two peak detectors/monitors monitor the integral course width parameter, only an alarm on one of them is required to initiate a transfer.
			Incorrect (low) DC output signal	The corresponding monitor channel processes the signal as being a drop in course RF power, an increase in modulation percentage, and a decrease in DDM. Now dependent upon 1 of 2 for course width monitoring. (Note that DDM is processed in the corresponding monitor channel).	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "ON" on corresponding sensitivity monitor channel.	0.386 λ_{NB}	
Standby Course Peak Detector	31	This peak detector receives its input signal directly from the standby transmitting unit after proper attenuation. It essentially converts the standby C+SB signal into a low frequency signal, both AC and DC. The DC component represents the standby RF power level; the AC component is the demodulated 90/150/1020 Hz signals.	Total loss of output signal (both AC and DC).	Loss of input signal to the standby course monitor. This, in turn, is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF and SDM lights "ON" on corresponding standby course monitor channel.	0.789 λ_{31A}	Although there will also be a loss of signal to the standby I. D. monitor, the standby inhibit signal will prevent the alarm from being processed.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\times 10^{-6}$)	Remarks
Standby Course Peak Detector (Continued)	31		Incorrect (low) DC output signal.	The standby course monitor recognizes this as being a failure in the standby transmitting unit and, hence, causes the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF and SDM lights "ON" on the corresponding standby course monitor channels.	0.386 λ_{31B}	
Standby Sensitivity Peak Detector	32	This peak detector receives its input signal from the standby transmitting unit. After proper attenuation, the input signal is a combination of standby course C+SB and SBO. This RF input signal is converted into a low frequency signal, both AC and DC. The DC component represents the course RF power level; the AC component is demodulated 90/150 Hz signal.	Total loss of output signal (both AC and DC)	Loss of input signal to the standby sensitivity monitor. This, in turn, is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF, SDM, and DDM lights "ON" on the corresponding standby sensitivity monitor.	0.789 λ_{32A}	
			Incorrect (low) DC output signal.	The standby sensitivity monitor recognizes this as being a drop in RF power, an increase in SDM, and a decrease in DDM. The decrease in DDM causes an alarm which, in turn, shuts down the standby transmitting unit.		X		"MON ABN" and "MAIN"	"ABN"	RF, SDM, and DDM lights "ON" on corresponding standby sensitivity monitor.	0.386 λ_{32B}	
Clearance Peak Detectors No. 1, No. 2, or No. 3 (MAIN)	26, 27, or 28	Each of the clearance peak detectors receives a simulated clearance input signal. This input signal is obtained by a combination of signals obtained by a combination of signals obtained from both proximity probes and a sampled signal of	Total loss of output signal (both AC and DC)	Loss of input signal to corresponding clearance monitor channel, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for clearance parameter monitoring.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "ON" on corresponding clearance monitor channel.	0.789 λ_{NA}	Although the remaining two peak detector/monitors monitor the clearance signal parameters, only an alarm on one of them is required to initiate a transfer.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate (λ x 10^6)	Remarks
Clearance Peak Detectors (Continued)	26, 27, or 28	clearance C-SB and SBO. This RF input signal is converted to a low frequency signal, both AC and DC. The DC is representative of the clearance RF power; the AC is the demodulated 90/150 Hz clearance signal		Now dependent upon 1 of 2 clearance monitors for system control.								
			Incorrect (low) DC output signal.	The corresponding monitor channel processes the failure as being a drop in clearance RF power, an increase in SDM, and a decrease in DDM. Now dependent upon 1 of 2 clearance monitor for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "ON" on the corresponding clearance monitor channel.	0.386 λNB	
Standby Clearance Peak Detector	33	This peak detector receives its input signal from the standby transmitting unit. After proper attenuation, this input signal is a combination of standby clearance C-SB and SBO. This RF input signal is converted into a low frequency signal, both AC and DC. The DC component represents the clearance RF power level, the AC component is the demodulated 90/150 Hz clearance signal.	Total loss of output signal (both AC and DC)	Loss of the input signal to the standby clearance monitor. This in turn is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF, SDM, and DDM lights "ON" on the corresponding clearance monitor.	0.789 λ33A	
			Incorrect (low) DC output signal.	The standby clearance monitor recognizes this as being a failure in the standby clearance transmitter and, hence, causes the entire standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF, SDM, and DDM lights "ON" on the corresponding standby clearance monitor.	0.386 λ33B	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Identification Monitor Assembly (I. D. MONITORS No. 1, No. 2, or No. 3)	34	Each I. D. monitor receives its respective input from the AGC outputs of the integral course position monitor channels. Each I. D. monitor checks its input signal for the presence of a keyed (coded) audio (1020 Hz) tone. An alarm is produced whenever a loss of audio or keying exists over a definite time interval.	Loss of monitoring ability of one of the main I. D. monitors, producing an alarm.	Loss of 2 of 3 I. D. monitor voting capability. Now dependen. upon 1 of 2 remaining I. D. monitors for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	I. D. Monitor alarm light "ON"	5.742 (total) λ_{34A1} = λ_{34A2} = λ_{34A3} = 1.914	If another such failure occurs in another I. D. monitor, the system will immediately transfer and then shut down.
			Loss of monitoring ability of one of the main I. D. monitors, producing no alarm.	Loss of 2 of 3 I. D. monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			(NONE)	(NONE)		1.050 λ_{34B}	Not hazardous - the I. D. signal is assumed non-essential for Cat III operation.
Identification Monitor Assembly (Standby I. D. Monitor)	34	Same as main I. D. monitors except it monitors the I. D. signal of the standby transmitter.	Loss of standby I. D. monitoring ability producing an alarm.	Causes the standby transmitting unit to shut down after a 2-5 sec time delay.		X		"MON ABN" and "MAIN"	"ABN"	Alarm on standby I. D. Monitor.	1.914 λ_{34C}	
			Loss of standy I. D. monitoring ability producing no alarm.	Loss of standby I. D. signal monitoring. Although the I. D. signal is not essential for Cat III operation, this failure mode can be hazardous. If a faulty I. D. signal occurs on the standby unit after this failure mode, then upon any transfer command an immediate shutdown will result.	X			(NONE)	(NONE)		0.350 λ_{34D}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^{-6}$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Identification Monitor Assembly (Regulator/ Alarm Logic)	34	The I.D. monitor assembly contains the 3 main I.D. monitors and the standby I.D. monitor. A common voltage regulator (+12, +15, -12V) supplies power to all monitors. The Cat III alarm logic is also contained within this assembly.	Loss of +12 volts of regulator.	All I.D. monitors (both main and standby) are rendered useless. No alarms are produced and, hence, Cat III operation continues. I.D. signal monitoring is totally lost.	X			(NONE)	(NONE)		0.423 λ_{34E}	Not hazardous - I.D. signal assumed not critical for Cat III operation.
			Loss of +5 volts of regulator.	I.D. alarm outputs (both main and standby) go to a "high" logic level. The control unit processes this as an immediate transfer and then a shutdown.			X	"MON ABN" and "OFF"	"ABN", "TRANSFER", and "SHUTDOWN"	I.D. Monitor Alarm lights will not be lit.	0.137 λ_{34F}	
			Loss of -12 volts of regulator.	Alarms on all I.D. monitors (both main and standby) causing an immediate transfer and then a shutdown.			X	"MON ABN" and "OFF"	"ABN", "TRANSFER", and "SHUTDOWN"	Alarm lights "ON" on I.D. No. 1, No. 2, No. 3 and standby I.D. monitor.	0.290 λ_{34G}	
			Alarm logic causing a main I.D. alarm.	The control unit processes this as an immediate transfer and then a shutdown.			X	"MON ABN" and "OFF"	"ABN", "TRANSFER", and "SHUTDOWN"	I.D. alarm lights will not be lit.	0.262 λ_{34H}	
			Alarm logic inhibiting the main I.D. alarm.	Loss of main I.D. monitoring ability.	X			(NONE)	(NONE)		0.434 λ_{34I}	Not hazardous - I.D. signal assumed not critical for Cat III operation.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λ x 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Identification Monitor Assembly (Regulator/ Alarm Logic) (Continued)	34		Alarm logic inhibiting the main I.D. alarm.	Shutdown of standby transmitting unit.		X		"MON ABN" and "MAIN"	"ABN"	Stby I.D. alarm light may or may not be lit.	0.172 λ_{34J}	
			Alarm logic inhibiting the standby I.D. alarm.	Loss of standby I.D. monitoring ability.	X			(NONE)	(NONE)		0.242 λ_{34K}	Hazardous - λ_{34K} is similar to λ_{34D}
			Alarm logic causing a mismatch.	No serious effect on system since a monitor mismatch does not effect Cat III operation.	X			"MON ABN" and "MAIN"	"MIS-MATCH" and "ABN"	No mismatch on monitor channels	0.160 λ_{34L}	Not hazardous.
Changeover and Test Circuits (Peak Detectors Excluded)	12	The changeover and test circuits provide the automatic changeover capability for the redundant transmitting units. It selects upon command from the control unit which transmitting unit radiates into the antennas and which unit operates into dummy loads.	Inability to changeover transmitting units by switching circuitry.	Although this failure mode does not immediately effect system operation, it does jeopardize Cat III status. This is due to the fact that any failure on the main unit, which should only generate a changeover to standby, will result in a system shutdown.	X			(NONE)	(NONE)		0.221 λ_{12A}	Essentially renders the standby unit useless.
			Premature transfer of transmitting units to antennas by switching circuitry.	If in MAIN, a transfer to STANDBY will occur; if in STANDBY, a transfer to OFF will occur. This is due to a momentary loss of signal.		X (assuming initial MAIN status)		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on some monitor channels.	0.134 λ_{12B}	Essentially renders either the main or standby transmitter useless.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Changeover and Test Circuits (Continued)	12		Failure causing a loss (or incorrect) signal to one of the standby monitors.	The alarm on the standby monitor will shutdown the standby transmitting unit - the main unit continues to operate normally.		X		"MON ABN" and "MAIN"	"ABN"	Alarm(s) on respective standby monitor channel.	0.782 λ_{12C}	A standby monitoring circuitry failure.
			Total loss (or incorrect phasing) of course SBO signal of the main transmitting unit.	Alarms on monitor channels initiate a transfer to standby and system operates on standby.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on sensitivity monitor channels.	0.070 λ_{12D}	
			Total loss (or incorrect phasing) of clearance SBO signal of the main transmitting unit.	Alarms on the clearance monitors initiate a transfer to standby and system operates on standby.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on clearance monitor channels.	0.070 λ_{12E}	
			Loss of any one or all of CSE C+SB, CSE SBO, CL C+SB, CL SBO, (to main transmitter)	Immediate shutdown after an automatic transfer.			X	"MON ABN" and "OFF"	"ABN", "TRANSFER" and "SHUTDOWN"	Alarms on some monitor channels.	2.417 λ_{12F} (Total) λ_{12F1} = 1/2 λ_{12F} = 1.209	λ_{12F} includes both the course and clearance failure rates.
Course Distribution Ckts (Peak Detectors Excluded)	13	The course distribution circuits serve two primary functions: (1) to route and distribute the course C+SB and SBO signals to the antennas; (2) to construct by use of proximity probes, bridge networks and phase shifters the signals used for monitoring course position,	A total loss of signal for any signal path; incorrect phasing of either the radiated signals or the detected signal; distortion sufficient to	Since a failure of this type is independent of the transmitting unit, an immediate shutdown after an automatic transfer will result.			X	"MON ABN" and "OFF"	"ABN", and "SHUTDOWN", and "TRANSFER"	Alarms on the sensitivity and/or course monitor channels.	0.859 λ_{13} λ_{13A} = 0.509	It should be noted that since any signal degradation sufficient to be "out of Cat III tolerance" has the same net effect, all possible failure modes may be treated on an aggregate basis. λ_{13A} is the failure rate of the circuitry required for signal radiation, i.e., up to and including the antennas.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Course Distribution Ckts (Continued)	13	course width, percent modulation, and RF power.	cause monitor alarms, i.e., out of Cat. III tolerance.									
Clearance Distribution Ckts (Peak Detectors Excluded)	14	The clearance distribution circuits perform two functions: (1) to route and distribute the clearance C+SB and SBO signals to the antennas; (2) to construct, by using the signals obtained by proximity detector probes, the signals for monitoring the clearance DDM, modulation percentage, and RF power.	A loss (or major distortion) of signal for any clearance signal path.	Upon failure, an immediate transfer followed by an immediate shutdown will occur. This is due to the fact that the circuitry is common to both transmitting units.			X	"MON ABN" and "OFF"	"ABN" and "TRANSFER" and "SHUT-DOWN"	Alarms on the clearance monitor channels.	1.032 λ_{14A}	SDM, DDM, and/or RF alarms on the monitors are dependent upon specific failures.
			A loss of signal (total or partial) to near field peak detectors.	Since the SDM is strapped with the DDM to provide an alarm, a shutdown will result after the nominal delay. Note that a shutdown alert will also be generated.			X	"MON ABN" and "OFF"	"ABN" and "SHUT-DOWN"	RF/SDM lights "ON" on both near field monitors.	0.040 λ_{14B}	It should be noted that the near field signal power divider and peak detectors are within the clearance distribution box.
Battery Charger No. 1 or No. 2	15 or 16	The two battery chargers, which are essentially in parallel, supply all the dc power to all the equipment of the localizer station. (The far field monitor has its own power source). In addition to supplying the power to the electronic equipment, each battery charger ensures that a full charge is constantly maintained on both batteries.	Loss of charger output voltage. (Note: the nominal output voltage is 30 volts DC)	When one charger fails (total loss of output voltage), the remaining charger supplies the necessary load voltage and current to continue normal operation. It also still supplies the voltage to maintain full charge on both batteries.	X	Downgrade to Cat II after time delay.		"PWR/ENVIR ABN" and "MAIN"	"ABN" and "CHARGER FAILURE"	"Charger fail" light "on" on charger.	10.477 λ_{NA}	Not hazardous - redundancy of remaining charger and the two batteries provide negligible probability of station shutdown.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Battery Charger No. 1 or No. 2 (Continued)	15 or 16	In the event of a primary power failure the two batteries (in parallel) supply the necessary dc power.	Charger failure indication only while output voltage is still maintained on both chargers.	No immediate effect on system operation - after the preset time delay the system will be falsely downgraded to Cat II status.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "CHARGER FAIL" and/or "AC POWER FAIL"	"Charger fail" and/ or "ac power fail" light "on" on respective charger.	0.801 λ_{NB}	Not hazardous - both transmitters still available after downgrade.
			Loss of equalize voltage capability - either manual and/or automatic. Note: the equalize voltage is a nominal 33 volts dc, thus providing a "hard charge" to the batteries.	With the loss at the equalize capability on one charger, the remaining charger can still provide the equalize capability as long as the batteries are not totally discharged.	X			(NONE)	(NONE)		6.436 λ_{NC}	Not hazardous - a total discharge of the batteries can occur only after the system is operated on batteries for some extended period of time (greater than 3 hours). System operation on batteries is a result of either primary or a failure of both chargers - both of which would downgrade performance to Cat II.
DC/DC Converter No. 1 or No. 2	17 or 18	Each of the DC/DC converters transfroms the +30 volts nominal input voltage to three different output voltages - +5.5v, -18v, and -50v. The output voltages of each converter are respectively used in parallel and feed both modulators in the system.	Loss of any one or all of the following voltages - +5.5v, -18v, -50v.	Station maintains normal operation on remaining converter voltages. Each of the converter voltages is sensed in the control unit for abnormal tolerances.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "CONVERTER FAIL"		6.598 λ_N	To result in a station shutdown both convertors must fail.
Temp Sensors	19	The temperature sensors provide alarm indications whenever the temperature exceeds or drops below preset limits. These limits are set to give indication of air conditioner/	Failure producing an alarm indication.	System maintains normal operation - only an erroneous failure indication.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "TEMP"		0.100 λ_{19A}	Not hazardous - both transmitters still available after downgrade.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate $(\lambda \times 10^6)$	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Temp Sensors (Continued)	19	heater failures.	Failure producing no alarm indication.	There are two sensors (thermocouples) - one for high temperatures and one for low temperatures. A failure of this type in one of the sensors does not effect the operation of the other. Hence, the only effect is the loss of temp. monitoring ability for only one temperature extreme (high or low).	X			(NONE)	(NONE)		0.100 λ_{19B}	Not hazardous - if temperature effects system operation, other alarms will occur.
Combining Circuits	49	The combining circuits assembly of the far field monitor processes the alarms of the monitor channels, the DC/DC convertors, the battery charger, and a temperature alarm. This processing includes the time delays necessary for far field monitor channel alarms.	Generation of an erroneous Cat III disable signal.	No effect other than falsely disabling Cat III status at the remote control tower.	X	Downgrade to Cat II after time delay.		None except "Cat II" after time delay.	(NONE)		0.676 λ_{49A}	Not hazardous - both transmitters still available after downgrade.
			Inability to generate a Cat III disable signal.	Inability to recognize far field Cat III "out of tolerance" conditions.	X			(NONE)	(NONE)		0.874 λ_{49B} λ_{49B1} = 0.102 λ_{49B2} = 0.530 λ_{49B3} = 0.242	Redundancy has been incorporated in the design to minimize the failure mode probability of occurrence.
			Generation of an erroneous Cat II monitor alarm.	After a nominal 70 second time delay, the entire localizer station will shutdown. Five seconds prior to shutdown, the shutdown alert signal is radiated.			X	"MON ABN" and "OFF"	"ABN", "SHUT-DOWN", and "FAR FIELD SHUT-DOWN"		0.512 λ_{49C}	Since this failure mode can lead directly to a shutdown without a Cat III disable, it is hazardous.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER FAR FIELD MONITOR

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate $(\lambda \times 10^6)$	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Combining Circuits (Continued)	49		Generation of a shut-down alert only.	No effect on system operation - only a false shutdown warning signal is generated.	X			(NONE)	(NONE)		0.514 λ_{49E}	Not hazardous - only psychological implications.
			Generation of a shut-down signal. (No warning)	Immediate shutdown of the entire localizer station with no warning signal generated prior to shutdown.			X	"MON ABN" and "OFF"	"ABN", "SHUT-DOWN" and "FAR FIELD SHUT-DOWN"		0.525 λ_{49E}	
			Inability to process a Cat II monitor alarm.	Loss of Cat II far field monitoring capability. Cat III disable signal still processed normally.	X			(NONE)	(NONE)		3.986 λ_{49F}	Not hazardous - Cat III far field monitoring still available.
			Inability to process a shutdown alert.	Loss of shutdown warning capability to pilot prior to shutdown due to a "true" far field alarm.	X			(NONE)	(NONE)		1.214 λ_{49G}	Not hazardous - shutdown warning not vital to system operation.
			Generation of an erroneous mismatch signal.	Only the input gating circuitry may be hazardous; mismatch conditions in themselves are not.	X			"MON ABN" and "MAIN"	"ABN" and "FAR FIELD MONITOR MISMATCH"		0.621 λ_{49H} (total) λ_{49HI} = 0.213	Only 49HI (input gates) effect actual monitoring circuitry which can be hazardous.
			Inability to process a mismatch condition at the FFM.	No serious effect on system - alarm status conditions are still processed normally.	X			(NONE)	(NONE)		1.476 λ_{49I}	Not hazardous - mismatch conditions do not effect Cat. III performance.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER FAR FIELD MONITOR

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Combining Circuits (Continued)	49		Generation of an erroneous pwr/temp alarm.	System falsely downgraded to Cat II status after a set time delay.	X	Downgraded to Cat II after time delay.		"POWER/ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/TEMP"	A power or temp light may or may not be "on" at ffm.	0.397 λ_{49J}	Not hazardous - both transmitters still available after downgrade.
			Generation of an erroneous pwr/temp alarm that is displayed only locally.	No effect on system operation whatsoever - only a false light "on" at far field monitor station.	X			(NONE)	(NONE)	"pwr" on "temp" light at the ffm.	0.436 λ_{49K}	Not hazardous.
			Inability to process a pwr/temp alarm for either remote or local display.	Loss of pwr/temp monitoring ability of the far field monitor.	X			(NONE)	(NONE)		0.852 λ_{49L}	Not hazardous - if power or temp do effect far field monitor performance, the monitors will alarm.
			Loss of dc output voltage on +5v regulator.	Immediate shutdown of the entire localizer station, caused by the generation of a shutdown signal from the far field monitor.			X	"MON ABN", "PWR/ENVIR ABN" and "OFF"	"ABN", "SHUTDOWN", "FAR FIELD SHUTDOWN", "FAR FIELD MISMATCH", "FAR FIELD PWR/TEMP"	At FFM no power or temp alarms displayed. Monitor channels will alarm after shutdown.	0.690 λ_{49M}	

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER FAR FIELD MONITOR

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Combining Circuits (Continued)	49		Loss of monitor enable signal.	Inability to turn on far field monitor channels, hence, losing all far field monitoring capability.	X	Downgrade to Cat II after time delay.		None except "Cat II" after time delay.	(NONE)		0.095 λ_{49N}	Not hazardous - both transmitters still available after downgrade. NOTE Design changes provided downgrade capability.
DC/DC Converter No. 1 or No. 2 (FFM)	51 or 52	Each of the DC/DC converters of the far field monitor provides -18v, used in the monitor channels and the receivers. They are in parallel and isolated by diodes.	Loss of -18 volts output.	System maintains operation on remaining converter. If the remaining converter also fails, the localizer station will be shut down, due to monitor channel alarms.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/ TEMP"	"CONV FAIL" light "on" at FFM.	2.412 λ_{NA}	
			Generation of an erroneous converter fail alarm.	System falsely downgraded to Cat II status after a set time delay.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/ TEMP"	"CONV FAIL" light "on" at FFM.	0.050 λ_{NB}	Not hazardous - both converters still operational after downgrade.
Battery Charger	50	The battery charger supplies +24 volts to each of the units at the far field monitor - the two converters, the three receivers and their respective monitor channels, and the combining circuits assembly. The battery charger also keeps a full charge on the battery at all times.	Loss of +24 volts output.	System maintains operation on far field monitor battery.	X	Downgrade to Cat II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/ TEMP"	"Charger FAIL" light "on" at FFM	5.790 λ_{50A}	
			"Low voltage" battery disconnect circuit failure, disconnecting the battery from the load.	If another failure of the battery charger causing loss of +24v occurs, immediate shutdown of the localizer station will result.	X			(NONE)	(NONE)		0.519 λ_{50B}	Note failure mode has the same effect as an ffm battery failure.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER FAR FIELD MONITOR

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate (λ x 10^6)	Remarks
Battery Charger (Continued)	50		Loss of equalize charge capability after a power outage.	Does not effect system operation. A trickle charge will still be applied to the battery.	X			(NONE)	(NONE)		0.318 λ_{50C}	Not hazardous - "quick charge" capability does not directly effect monitoring performance.
			Generation of an erroneous charger fail alarm	System falsely downgraded to Cat II status after a set time delay.	X	Downgrade to Cat II after time delay.		"PWR/ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/TEMP"	"Charger FAIL" light "on" at FFM.	0.126 λ_{50D}	Not hazardous - far field monitoring not effected.
			Continuous equalize voltage only.	Far field monitor maintains normal operation at a slightly higher supply voltage.	X			(NONE)	(NONE)		7.658 λ_{50E}	Not hazardous - preventive maintenance required for battery check.
Receiver No. 1, No. 2, or No. 3	53, 54, or 55	Each of the far field monitor receivers receives a low level rf input signal and converts it to the ILS audio and dc signal which is then the input to the respective monitor channel. The DDM of the audio signal is representative of the far field course position.	Total loss of output signal or any major signal distortion.	Loss of the input signal to the corresponding far field monitor channel will produce a FFM monitor mismatch. Loss of 2 of 3 FFM monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system operation.	X			"MON ABN" and "MAIN"	"ABN" and "FAR FIELD MONITOR MISMATCH"	RF and SDM lights "on" on the corresponding monitor channel.	0.879 λ_N	The SDM strap option provided remote recognition of failure.
Monitor Channels No. 1, No. 2, or No. 3	56, 57, or 58	To provide monitoring of the course position in the far field region of the runway. It provides both Cat III and Cat II alarm limit monitoring.	Loss of monitoring ability, producing a Cat III DDM alarm.	Loss of 2 of 3 monitor voting capability for the Cat III alarms. Now dependent upon 1 of 2 remaining monitors for Cat III performance status.	X			(NONE)	(NONE)		0.825 λ_{NA}	Not hazardous - far field Cat III monitoring cannot lead to a shutdown, only a performance degradation.

Table C-1. Localizer Failure Analysis (Cont'd)

System SSILS
Subsystem LOCALIZER FAR FIELD MONITOR

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Monitor Channels (Continued)	56, 57, or 58		Loss of monitoring ability producing Cat II DDM alarm.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system operation.	X			"MON ABN" and "MAIN"	"ABN" and "FAR FIELD MONITOR MISMATCH"	DDM light "on" at FFM.	11.099 λ_{NB}	A Category III DDM alarm may or may not be produced.
			Loss of monitoring ability producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitor for far field monitoring.	X			(NONE)	(NONE)		4.422 λ_{NC}	Note that this failure mode applies to either or both Cat III or Cat II DDM alarms.
Temp. Sensor	59	Monitors the temperature of the FFM for out of tolerance conditions.	Generation of an erroneous temp. alarm.	System falsely downgraded to Cat II status after a set time delay	X	Downgrade to Cat II after time delay.		"POWER/ENVIR ABN" and "MAIN"	"ABN" and "FAR FIELD PWR/TEMP"	Temp alarm light "on" at FFM.	0.050 λ_{59A}	Not hazardous - far field monitoring still available after downgrade.
			Inability to produce a temp. alarm.	Loss of temperature monitoring ability without recognition.	X			(NONE)	(NONE)		0.050 λ_{59B}	Not hazardous - if temperature effect monitoring, alarms will occur.

Appendix D

Glideslope Failure Analysis

Appendix D

Glideslope Failure Analysis

This appendix, referred to in section 7.0, consists of the failure analysis for the glideslope, as shown in table D-1.

Table D-1. Glideslope Failure Analysis

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Course Transmitter (MAIN or STANDBY)	02 or 06 (N)	The course transmitter in conjunction with the 10 watt amplifier delivers a UHF carrier to the modulator.	Loss or degradation of UHF carrier.	Loss of all course signal radiation, effecting the entire glidepath angle and width.		X		MON ABN and STBY	"ABN" and "TRANSFER"	Alarms on course, sensitivity and near field monitors.	6.734 λ_N	Failure of standby unit keeps "main" operational and shuts standby down. NOTE Although near field monitor lights are "on", their alarms are not processed.
Clearance Transmitter (MAIN or STANDBY)	04 or 08	The clearance transmitter supplies a UHF carrier modulated at 150Hz which is used to ensure low approach angle coverage.	Loss or degradation of the 150Hz modulation.	Loss of clearance coverage of approach angle. (Pure carrier radiated)		X		MON ABN and STBY	ABN and TRANSFER	"SDM AND DDM" lights on clearance monitors.	1.914 λ_{NA}	Failure of standby unit keeps "main" operational and shuts standby down.
			Loss or degradation of UHF carrier.	Loss of clearance coverage of approach angle.		X		MON ABN and STBY	ABN and TRANSFER"	"SDM", "DDM", AND "RF" lights on clearance monitors.	6.734 λ_{NB}	
10 Watt Amplifier (MAIN or STANDBY)	05 or 09	The 10 watt amplifier merely amplifies the course UHF carrier.	Loss or degradation of UHF carrier.	Loss of all course signal radiation.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on course, sensitivity, and near field monitors.	0.686 λ_N	Failure of standby unit keeps "main" operational and shuts standby down.
Modulator (MAIN or STANDBY)	03 or 07	Provides course UHF carrier amplitude modulated by a 90Hz and 150 Hz signal, CSE C+SB. It provides the course SBO signal; a low frequency 150Hz signal which feeds the clearance transmitter.	Loss of low frequency oscillator (14.4 kHz) resulting in loss of all 90Hz and 150Hz modulation.	Loss of the following system signals: 1. LF 150 2. SB in clearance C+SB 3. Course SBO 4. SB in course C+SB		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, near field, and clearance monitors on main cabinet.	2.613 λ_{NA}	"Transfer" would not occur on failure of standby unit. Loss of Cat. III status would occur even though "main" is still operational.
			Loss of UHF carrier to digital phasing ckts. (to either or both of the 90 and 150 phase shifter)	Loss of SB in course C+SB signal and course SBO signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course sensitivity, and near field monitors.	0.427 λ_{NB}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Modulator (MAIN or STANDBY) (continued)	03 or 07		Loss of 90 or 150 Hz dividers, synchronization circuitry or 90/150Hz shift registers.	Out of tolerance course C+SB and SBO and clearance C+SB signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, near field and clearance monitors.	1.453 λ_{NC}	
			Loss of λ_{32} driving signal to delay line (either the 90Hz or 150 Hz phase shifter).	Slight distortion of the course C+SB and SBO signals.	X			NONE	NONE		2.426 λ_{ND}	Not-hazardous-signal still within Cat. III tolerance.
			Loss of λ_{16} driving signal to the delay lines (either the 90Hz or 150Hz phase shifters).	Distortion somewhat more than λ_{32} of the course C+SB and SBO signals.	X			NONE	NONE		2.426 λ_{NE}	Not-hazardous-signal still within Cat. III tolerance.
			Loss of λ_8, λ_4, λ_4, λ_2, or λ_2 signal to the delay line. (either the 90Hz or 150 Hz phase shifters)	Out of tolerance course C+SB and SBO signals.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, and near field monitors.	12.832 λ_{NF}	
			Loss of +90, -90, +150, or -150Hz phase shifter RF signal.	Out of tolerance C+SB signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all course, sensitivity, and near field monitors.	1.302 λ_{NG}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Modulator (continued)			Loss of the 150Hz sinusoidal signal for clearance transmission.	Out of tolerance clearance C+SB signal.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on all clearance monitors.	1.176 NH	
Course Monitor Channels (1, 2, or 3) (MAIN)	34, 35, or 36	Provide monitoring of the course position path angle (DDM), the modulation (SDM) and the course UHF power level.	Loss of monitoring ability producing alarms.	Loss of 2 of 3 monitor voting capability. Now dependent on 1 of 2 remaining monitors for system control.	X			MON ABN and MAIN	MONITOR MISMATCH and ABN	Alarm light(s) on defective monitor channel.	12.689 NA	If another corresponding monitor alarm failure occurred in one of the remaining two monitors, immediate glideslope shutdown will result.
			Loss of monitoring ability producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		4.836 NB	
Course Monitor Channel (STANDBY)	46	Same as main course monitor channels except monitors course parameters of standby unit.	Loss of monitoring ability producing alarms.	Shutdown of standby transmitter.		X		MON ABN and MAIN	ABN	Alarm light(s) on standby course monitor.	12.689 46A	
			Loss of monitoring ability producing no alarms.	Loss of standby course monitoring.	X			NONE	NONE		4.836 46B	
Sensitivity Monitor Channels 1, 2, or 3 (MAIN)	37, 38, or 39	Provide monitoring of the the course width (DDM)	Loss of monitoring ability producing alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system control.	X			MON ABN and MAIN	MONITOR MISMATCH and ABN	Alarm light(s) on defective monitor channel.	9.367 NA	If another corresponding monitor DDM failure occur red in one of the remaining two monitors, immediate glideslope shutdown will result.
			Loss of monitoring ability producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		2.892 NB	Only DDM monitoring circuitry is critical.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Standby Sensitivity Monitor Channel	47	Provide monitoring of the standby course width (DDM).	Loss of monitoring ability producing alarms.	Shutdown of the standby transmitter.		X		"MON ABN" and "MAIN"	"ABN"	Alarm light(s) on standby sensitivity monitor.	9.367 λ_{47A}	Only DDM monitoring circuitry is critical.
			Loss of monitoring ability producing no alarms.	Loss of standby course monitoring.	X			NONE	NONE		2.892 λ_{47B}	
Near Field Monitor Channels 1, 2, or 3	43, 44, or 45	Provide monitoring of the near field course position path angle (DDM)	Loss of monitoring ability producing alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system control.	X			"MON ABN and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective near field monitor.	11.099 λ_{NA}	SDM and DDM are strapped to provide one general alarm output.
			Loss of monitoring ability producing no alarms.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		3.822 λ_{NB}	
Clearance Monitor Channels #1, 2 or 3 (MAIN)	40, 41, or 42	Provide monitoring of the clearance DDM, % modulation, and clearance UHF power level.	Loss of monitoring ability producing alarm.	Loss of 2 of 3 monitor voting capability. Now dependent upon 1 of 2 remaining monitors for system control.	X			"MON ABN" and "MAIN"	"MONITOR MISMATCH" and "ABN"	Alarm light(s) on defective clearance monitor.	13.044 λ_{NA}	If another corresponding monitor alarm failure occurred in one of the remaining two monitors, immediate glideslope shutdown will result.
			Loss of monitoring ability producing no alarm.	Loss of 2 of 3 monitor voting capability. Now dependent upon 2 of 2 remaining monitors for system control.	X			NONE	NONE		4.848 λ_{NB}	
Clearance Monitor Channel (STANDBY)	48	Same as Main Clearance Monitor Channels except monitors clearance parameters of standby unit.	Loss of monitoring ability producing alarm.	Shutdown of standby transmitter.		X		"MON ABN" and "MAIN"	"ABN"	Alarm light(s) on standby clearance monitor.	13.044 λ_{48A}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Clearance Monitor Channel (STANDBY) (continued)			Loss of moni-toring ability producing no alarm.	Loss of standby clearance monitor-ing.	X			NONE	NONE		4.848 λ 48B	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit	01	The control unit processes alarms received from the monitor channels, providing signals to shutdown the standby transmitter, to transfer main to standby, to shutdown both transmitters, or to indicate a monitor mismatch. In addition, the control unit generates inhibit signals, displays both locally and remotely transmitter and category status, and displays various power temperature alarm conditions operational features, such as bypass of monitors, main unit select, memorization of alarms are also associated with the control unit.	Generation of an erroneous transfer signal, due to alarm processing circuitry.	Causes both the main and the standby transmitter to shutdown immediately after the transfer.			X	"MON ABN" and OFF	"TRANSFER", "SHUTDOWN", and "ABNORMAL"		2.895 λ_{1A}	
			Generation of an erroneous shut-down signal due to alarm processing circuitry.	Causes both the main and the standby transmitter to shutdown immediately.			X	"MON ABN and "OFF"	"SHUTDOWN" and "ABNORMAL		2.004 λ_{1B}	
			Generation of an erroneous mismatch signal.	Mismatch conditions do not effect category performance; however, failure of input gates may be hazardous.	X			"MON ABN" and "MAIN"	"MISMATCH" and "ABNORMAL"	No mismatch on monitor channels.	2.888 (λ_{1C1} = 0.42) (λ_{1C2} = 0.14) (λ_{1C3} = 0.14) (λ_{1C4} = 0.42)	Only input gating circuit-RY may be hazardous. (Effects monitoring circuitry)
			Inability to process a transfer signal from the integral course, sensitivity and/or clearance monitors.	*Cat. III parameter monitoring of the integral course, sensitivity, and/or clearance is virtually rendered useless.*	X			NONE	NONE		3.470 λ_{1D3} = 1.249 (redund) λ_{1D1} = 0.140 (gate) λ_{1D2} = 0.700 (logic)	Redundancy has been incorporated so that performance downgrade is achieved in the event of a "true Cat. III alarm condition."

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (continued)	01		bility to cess a shutdown signal, initiated by the misalignment at detector.	Results in a loss of tower alignment monitoring.	X			NONE	NONE		1.102 λ_{1E}	
			Inability to process a shutdown signal, initiated by either a double transfer or the near field alarms.	System will continue to radiate a signal (possibly faulty) during a shutdown status.	X			NONE	NONE		1.737 λ_{1F}	Redundancy has been incorporated so that performance down grade is achieved in the event of a 'true near field alarm condition'.
			Inability to process a mismatch condition of any or all monitor sets.	No serious effects on system operation. Monitor mismatches may not be recognized, but parameter out of tolerance conditions are still processed normally.	X			NONE	NONE		3.746 λ_{1G}	Not hazardous-mismatch conditions do not effect Cat. III performance.
			Inability to process a standby alarm	Standby unit monitoring is rendered useless.	X			NONE	NONE		1.390 λ_{1H}	If a standby transmitter failure also occurs, immediate shutdown upon transfer will result.
			Generation of an erroneous standby alarm.	Causes the standby transmitter to shutdown. Main continues to operate in Cat. II status.		X		'MON ABN and "MAIN'	"ABNORMAL"	No alarms on stby. monitors.	1.164 λ_{1I}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System: SSILS
Subsystem: GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λ x 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (continued)	01		Inability to process any or all power/environmental alarms.	Loss of remote recognition of respective alarm conditions: loss of downgrade capability due to power/environmental alarms.	X			NONE	NONE		2.369 λ_{1J}	Not hazardous-power/environmental alarms merely downgrade performance after a time delay yet both transmitter are still available.
			Generation of an erroneous battery alarm	No effect other than erroneously downgrading the system to Cat. II status.		X		"POW/ENVIR ABN and 'MAIN'	"ABNORMAL and BATT.. FAIL.		0.415 λ_{1K}	Not hazardous-system still has the ability to operate on both transmitting units.
			Generation of any erroneous power/environmental alarm except a battery alarm.	No effect other than an erroneous abnormal indication.	X	Downgrade to Cat. II af after time delay.		"POW/ENVIR ABN" and "MAIN"	"ABNORMAL and possibly the respective power or temperature alarm light.		1.775 λ_{1L}	Not hazardous.
			Generation of an erroneous control signal that shuts down the main transmitting unit.	After the main transmitter shuts down, the loss of radiation is detected by the monitor channels and transfer is initiated to the standby unit.		X		"MON ABN" and "STBY"	"TRANSFER" and "ABN"	Alarms on some monitor channels.	0.420 λ_{1M}	Monitor channel alarm lights are unpredictable due to a race condition between the generated inhibit signal and the "no signal" input alarm processing.
			Generation of an erroneous control signal that shutdown the standby transmitting unit	After the standby transmitter shuts down, the loss of input signals to the standby monitor channels creates standby alarm conditions which are processed normally in the control unit.		X		"MON ABN" and "MAIN"	"ABN"	Alarms on some standby monitor channels.	0.280 λ_{1N}	This failure mode is not generated by monitoring circuitry; hence, it may occur after a transfer to standby has occurred.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λ x 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Control Unit (continued)	01		Generation of an erroneous control signal that shuts down both transmitting units.	After a total shutdown is initiated, the loss of input signals to all monitor channels results in both a simultaneous processing of a transfer and shutdown condition in the control unit			X	MON ABN and OFF	TRANSFER, SHUTDOWN and ABN	Alarms on some monitor channels.	0.140 1O	
			Inability to shutdown either the main or the standby transmitting unit.	No failure effect or indication until another failure occurred in the main or standby unit. At that time all control signals would be processed normally, except the respective transmitting unit would not cease transmission.	X			NONE	NONE		1.782 1P	Not hazardous-performance category downgrade still possible. Note also that transfer capability still exists; hence, Cat. III performance is not effected.
			Inability to effect a change of units feeding the antennas.	No failure effect or indication until a transfer command is received (due to some other failure). At that time all radiation will cease.	X			NONE	NONE		0.844 1Q	Essentially renders the standby transmitter useless.
			Pre-mature change of units feeding the antennas.	If in MAIN, a transfer to STANDBY will occur; if in STANDBY, a transfer to OFF will occur. This is due to a momentary loss of signal.		X (assuming initial MAIN status)		MON ABN and STBY	TRANSFER and ABN	Alarms on some monitor channels.	0.960 1R	Essentially renders either the main or standby transmitter useless.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Control Unit (continued)	01		Generation of a continuous main and/or standby inhibit to the monitor channels.	The respective main and/or standby monitor channels are inhibited and hence, rendered totally useless.			X	MON ABN and MAIN	ABNORMAL		2.514 λ_{1S} λ_{1S1} =0.198 (stby. inhibit) λ_{1S2} =2.316 (main inhibit)	Upon the generation of a continuous main inhibit, design modifications have been incorporated to take away Cat. III and Cat. II status. Although both transmitters may still be good, all monitoring is lost. λ_{1S1} is similar to λ_{1H}.
			Inability to process a main inhibit to the monitor channels.	If another failure occurs which initiates a transfer, an immediate shutdown will occur since the monitors are not inhibited during the transition period.	X			NONE	NONE		2.658 λ_{1T}	Failure mode virtually renders the standby transmitter useless.
			Inability to process a standby inhibit to the standby monitor channels.	No effect on system operation-merely produces alarms on all standby monitor channels after a transfer has already occurred due to another failure.	X			NONE	NONE		0.370 λ_{1U}	Not hazardous-standby monitoring is meaningless after a transfer.
			Generation of an erroneous monitors locally bypassed signal.	The control unit cannot process transfer and shutdown command signals and, hence, the entire monitoring is rendered useless.			X	"ABNORMAL" flashing and "MAIN"	"MON LOC BYPASS" and "NORMAL"		0.140 λ_{1W}	Cat. III and Cat. II status taken away although both transmitters are still operational.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Control Unit (continued)			Loss of -12 volts in control unit power supply.	All delay circuits produce an alarm output: both a continuous main and standby inhibit are generated. An immediate shutdown will result due to the near field delay circuits.			X	"MON ABN" and "OFF"	"TRANSFER", "SHUTDOWN", "ABNORMAL"	No alarms present on main cabinet due to inhibit.	0.339 λ_{1X}	
			Loss of +12 volts in control unit power supply. (Note: loss of switched 28v is also included.)	All control logic is rendered useless. Both transmitters shutdown; monitors channels, however, are inhibited and, hence, do not alarm.			X	"POW/ENVIR ABN" and "OFF"	ALL FRONT PANEL LIGHTS OFF.		1.464 λ_{1Y}	
Near Field Peak Detector #1, #2, or #3	28, 29, or 30	Each of the near field peak detectors receives its input signal from a near field antenna. The received RF signal is representative of the course path alignment. Each peak detector then converts the RF signal into a low frequency signal to be processed by its respective monitor.	Loss of detected output signal.	Loss of the input signal to the corresponding near field monitor channel, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for near field monitoring now dependent upon 1 of 2 near field parameter monitors for system control. Shutdown will result if one of the remaining two peak detector/monitors also fails.	X			"MON ABN" and "MAIN"	"ABN" and "MISMATCH"	RF and SDM lights "on" on the corresponding near field monitor channel	1.115 λ_N	The strap option for SDM alarms will be employed to detect "no signal" input conditions.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx10)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Course Peak Detectors #1, #2, or #3 (MAIN)	19, 20, or 21	Each of the course peak detectors receives a simulated course position input signal. This input signal is obtained by a combination of signals obtained by proximity probes at the radiating antennas. Each peak detector then converts the RF signal into a low frequency signal.	Loss of detected output signal.	Loss of input signal to corresponding monitor, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for integral course position (path angle) monitoring. Now dependent upon 1 of 2 course parameter monitors for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF and SDM lights "on" on corresponding course monitor channel.	1.115 λ_N	Note that although both the remaining two peak detectors/monitors monitor integral course position, only an alarm on one of them is required to initiate a transfer.
Sensitivity Peak Detectors #1, #2, or #3 (MAIN)	22, 23, or 24	Each of the sensitivity peak detectors receives a simulated input signal, representative of the course width (path angle width). This input signal is obtained by a combination of signals obtained by proximity probes at the radiating antennas. Each peak detector converts the RF signal into a low frequency signal.	Loss of detected output signal.	Loss of input signal to corresponding sensitivity monitor channel, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for integral course width monitoring. Now dependent upon 1 of 2 monitoring for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "on" on corresponding sensitivity monitor channel.	1.115 λ_N	Although the remaining two peak detectors/monitors monitor the integral course width parameter, only an alarm on one of them is required to initiate a transfer.
Standby Course Peak Detector	31	This peak detector receives its input signal directly from the standby transmitting unit after proper attenuation. It essentially converts the standby CSE C+SB signal into a low frequency signal.	Loss of detected output signal.	Loss of input signal to the standby course monitor. This, in turn, is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF and SDM lights "on" on the corresponding standby course monitor channel.	1.115 λ_{31}	Although there will also be a loss of signal to the standby I.D. monitor, the standby inhibit signal will prevent the alarm from being processed.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Standby Sensitivity Peak Detector	32	This peak detector receives its input signal from the standby transmitting unit. After proper attenuation, the input signal is a combination of standby course C+SB and SBO. This RF input signal is converted into a low frequency signal.	Loss of detected output signal.	Loss of input signal to the standby sensitivity monitor. This, in turn, is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and "MAIN"	"ABN"	RF, SDM, and DDM lights "on" on the corresponding standby sensitivity monitor.	1.115 λ_{32}	
Clearance Peak Detectors #1, #2, or #3 (MAIN)	25, 26, or 27	Each of the clearance peak detectors receives a simulated clearance input signal. This input signal is obtained by a combination of signals obtained from both proximity probes. This RF input signal is then converted to a low frequency signal.	Loss of detected output signal.	Loss of input signal to corresponding clearance monitor channel, causing a monitor mismatch. Dependence upon remaining two peak detectors/monitors for clearance parameter monitoring. Now dependent upon 1 of 2 clearance monitors for system control.	X			"MON ABN" and "MAIN"	"ABN" and "MIS-MATCH"	RF, SDM, and DDM lights "on" on corresponding clearance monitor channel.	1.115 λ_N	Although the remaining two peak detector/monitors monitor the clearance signal parameters only an alarm on one of them is required to initiate a transfer.
Standby Clearance Peak Detector	33	This peak detector receives its input signal from the standby transmitting unit. After per attenuation, this input signal is simply the standby clearance C+SB signal. This RF input signal is then converted into a low frequency signal.	Loss of detected output signal.	Loss of the input signal to the standby clearance monitor. This, in turn, is processed as a failure in the standby transmitting unit, causing the standby unit to be shut down.		X		"MON ABN" and MAIN"	"ABN"	RF, SDM, and DDM lights "on" on the corresponding clearance monitor.	1.115 λ_{33}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Changeover and Test Circuits (Peak Detector Excluded)	10	The changeover and test circuits provide the automatic changeover capability for the redundant transmitting units. It selects upon command from the control unit which transmitting unit radiates into the antennas and which unit operates into dummy loads.	Inability to changeover transmitting units by switching circuitry.	Although this failure mode does not immediately effect system operation, it does jeopardize Cat. III status. This is due to the fact that any failure on the main unit, which should only generate a changeover to standby, will result in a system shutdown.	X			NONE	NONE		0.221 λ_{10A}	Essentially renders the standby unit useless.
			Pre-mature transfer of transmitting units to antenna by switching circuitry.	If in MAIN, a transfer to STANDBY will occur; if in STANDBY, a transfer to OFF will occur. This is due to a momentary loss of signal.		X (assuming initial MAIN status)		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on some monitor channels.	0.134 λ_{10B}	Essentially renders either the main or standby transmitter useless.
			Failure causing a loss (or incorrect) signal to one of the standby monitors.	The alarm on the standby monitor will shut down the standby transmitting unit - the main unit continues to operate normally.		X		"MON ABN" and "MAIN"	"ABN"	Alarm(s) on respective standby monitor channel.	0.572 λ_{10C}	A standby monitoring circuitry failure.
			Total loss (or incorrect phasing) of course SBO signal of the main transmitting unit.	Alarms on monitors channels initiate a transfer to standby and system operates on standby.		X		"MON ABN" and "STBY"	"ABN" and "TRANSFER"	Alarms on sensitivity monitor channels.	0.070 λ_{10D}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	Cat II	Off	Failure Indications: Remote Control	Control Unit	Other	Failure Rate ($\lambda \times 10^6$)	Remarks
Changeover and Test Circuits (continued)	10		Loss of any one or all of: CSE C+SB, CSE SBO, CL C+SB, (to main transmitter)	Immediate shutdown after an automatic transfer			X	"MON ABN" and "OFF"	"ABN", "TRANS-FER" and "SHUT-DOWN"	Alarms on some monitor channels.	1.951 λ_{10E} = λ_{10E1} 0.466 (each pin switch circuit)	
Distribution Circuits (Antennas included)	11	The UHF distribution circuits combine and distribute the CSF C+SB, CSF SBO, and CL C+SB signals to the three 2-lambda antennas.	A loss, degradation, or incorrect phasing of any signal feeding any one of the three antennas.	Since a failure of this type is independent of the transmitting unit (signal paths common to both transmitters), an immediate shutdown after an automatic transfer will result.			X	"MON ABN" and "OFF"	"ABN" and "TRANS-FER" and "SHUT-DOWN"	Alarms on any or all of the monitor channels.	1.231 λ_{11}	It should be noted that since any signal degradation sufficient to be "out of Cat. III tolerance" has the same net effect, all possible failure modes may be treated on an aggregate basis.
UHF Recombining Circuits and Probes (peak detectors excluded)	12	The UHF recombining circuits, receiving inputs from proximity detector probes, combine the CSE C+SB, CSE SBO and CL C+SB to provide inputs to monitors for monitoring the course position, displacement sensitivity, and clearance radiation.	A loss, degradation, or incorrect phase of any signal feeding any of the monitors.	The actual field radiation is unaffected. However, the monitor channels believe an "out of tolerance" condition exists and initiate a transfer, since the circuitry is common to both transmitting unit, the monitors will again sense an "out of tolerance" condition and initiate a shutdown.			X	"MON ABN" and "OFF"	"ABN" and "TRANS-FER" and "SHUT-DOWN"	Alarms on any or all of the monitor channels.	0.778 λ_{12}	
Near Field Antenna and Power Splitter (peak detectors excluded)	18	Provides the input for the three near field monitors.	A loss or degradation of signal feeding the monitors.	The erroneous (or total loss of) signal is processed as a near field alarm, resulting in a transfer and a shutdown after the nominal time delay			X	"MON ABN" and "OFF"	"ABN" and "TRANS-FER" and "SHUT-DOWN"	Alarms on near field monitors.	0.098 λ_{18}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate (λx 10^6)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Battery Charger #1 or #2	13 or 14	The two battery chargers which are essentially in parallel, supply all the electric power to all the equipment of the glide-slope station. In addition to supplying the power to the electronic equipment, each battery charger ensures that a full charge is constantly maintained on both batteries.	Loss of charger output voltage (Note: the nominal output voltage is 30 volts DC)	When one charger fails (total loss of output voltage), the remaining charger supplies the necessary load voltage and current to continue normal operation. It also still supplies the voltage to maintain full charge on both batteries.	X	Down-grade to Cat. II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "CHARGER FAILURE"	"charger fail" light "on" on charger.	10.477 λ_{NA}	Not hazardous-redundancy of remaining charger and the two batteries provide negligible probability of station shutdown.
		In the event of a primary power failure the two batteries (in parallel) supply the necessary DC power.	Charger failure indication only while output voltage is still maintained on both chargers.	No immediate effect on system operation-after the pre-set time delay the system will be falsely downgraded to Cat. II status.	X	Down-grade to Cat. II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "CHARGER FAILURE" and/or "AC POWER FAIL"	"charger fail" and/ or "AC power fail" light "on" on respective charger.	0.801 λ_{NB}	Not hazardous-both transmitters still available after downgrade.
			Loss of equalize voltage capability-either manual and/ or automatic. Note: the equalize voltage is a nominal 33 volts DC, thus providing a "hard charge" to the batteries.	With the loss of the equalize capability on one charger, the remaining charger can still provide the equalize capability as long as the batteries are not totally discharged.	X			NONE	NONE		6.436 λ_{NC}	Not hazardous-a total discharge of the batteries can occur only after the system is operated on batteries for some extended period of time (greater than 3 hours). System operation on batteries is a result of either primary power failure or a failure of both chargers - both of which would downgrade performance to Cat. II.

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification: Item Name	Identification: I.D. No.	Function	Failure Mode	Failure Effect	System Operation After Failure: Cat III	System Operation After Failure: Cat II	System Operation After Failure: Off	Failure Indications: Remote Control	Failure Indications: Control Unit	Failure Indications: Other	Failure Rate (λx 10^6)	Remarks
DC/DC Converter #1 or #2	15 or 16	Each of the DC/DC converters transforms the +30 volts nominal input voltage to three different output voltages - +5.5V, -18V, and -50V. The output voltages of each converter are respectively used in parallel and feed both modulators in the system.	Loss of any one or all of the following voltages: +5.5V, -18V, -50V.	Station maintains normal operation on remaining converter voltages. Each of the converter voltages is sensed in the control unit for abnormal tolerances.	X	Downgrade to Cat. II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "CONVERTER FAIL"		6.598 λ_N	To result in a station shutdown both converters must fail.
Temp Sensors	17	The temperature sensors provide alarm indications whenever the temperature exceeds or drops below pre-set limits. These limits are set to give indication of air-conditioner/heater failures.	Failure producing an alarm indication.	System maintains normal operation - only an erroneous failure indication.	X	Downgrade to Cat. II after time delay.		"PWR/ ENVIR ABN" and "MAIN"	"ABN" and "TEMP"		0.100 λ_{17A}	Not hazardous - both transmitters still available after downgrade.
			Failure producing no alarm indication.	There are two sensors (thermocouples) one for high temperatures and one for low temperatures. A failure of this type in one of the sensors does not effect the operation of the other. Hence, the only effect is the loss of temp. monitoring ability for only one temperature extreme (high or low).	X			NONE	NONE		0.100 λ_{17B}	Not hazardous - if temperature effects system operation, other alarms will occur.
Misalignment Detector	49	The misalignment detector detects permanent misalignment or deformation of the glideslope antenna tower. A nominal 135 seconds delay is provided to process alarms, since tower vibrations and wind loadings can occur.	Loss of alignment detection, producing an alarm.	Erroneous shutdown of the glideslope station.			X	"MON ABN" and "OFF"	"ABN" and "SHUTDOWN" and "MISALIGNMENT DETECTOR ALARM"		4.915 λ_{49A}	

Table D-1. Glideslope Failure Analysis (Cont'd)

System SSILS
Subsystem GLIDESLOPE STATION

Identification		Function	Failure Mode	Failure Effect	System Operation After Failure			Failure Indications			Failure Rate ($\lambda \times 10^6$)	Remarks
Item Name	I.D. No.				Cat III	Cat II	Off	Remote Control	Control Unit	Other		
Misalignment Detector (continued)			Loss of alignment detection, producing no alarm.	Although the near field monitors detect field radiation, an erroneous signal radiation can still exist since tower misalignment in the horizontal plane chiefly effects the width of the glide path angle and the clearance radiation.	X			NONE	NONE		2.354 λ_{49B}	Design modifications have incorporated a "quick test functional check.

Appendix E

Localizer Math Models

Appendix E

Localizer Math Models

This appendix consists of tables E-1 and E-2, referred to in section 8.0, which give, respectively, probability math models for localizer hazardous signal radiation and shutdown.

Table E-1. Localizer Hazardous Signal Radiation Probabilities

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Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous course position Cat. III DDM signal due to equipment failure. Note: Far field hazardous DDM signal due to external runway disturbances is not included in this calculation.	$P(HS)_{CSE_{DDM}} = P_{INT_{CSE_{DDM}}}$ $\times P_{MON_{FF}}$ $\times P_{XMTR_{CSE_{DDM}}}$ $P_{INT_{CSE_{DDM}}} = (\lambda_{MON_{CSE}} \cdot 168)^2$ $+ (\lambda_{GATE} \cdot 168)^3$ $+ (\lambda_{LOGIC} \cdot 168)$ $\times (\lambda_{REDUND} \cdot 168)$ $P_{MON_{FF}} = (\lambda_{MON_{FF}} \cdot 168)^2$ $+ (\lambda_{GATE_{FF}} \cdot 168)^3$ $+ [(\lambda_{LOGIC_{FF}} \cdot 168)$ $\times (\lambda_{REDUND_{FF}} \cdot 168)]$ $P_{XMTR_{CSE_{DDM}}} = (\lambda_{XMTR_{CSE_{DDM}}} \cdot 168)$ $P_{INT_{CSE_{DDM}}} =$ The probability of failure of course Cat. III DDM integral monitoring circuitry. (hidden failure) $P_{MON_{FF}} =$ The probability of a hidden failure in the far field Cat. III DDM monitoring circuitry.	$\lambda_{MON_{CSE}} = \lambda_{35B} + \lambda_{36B}$ $+ \lambda_{37B} = 5.390 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{MON_{FF}} = \lambda_{56C} + \lambda_{57C}$ $+ \lambda_{58C} = 4.422 \times 10^{-6}$ $\lambda_{GATE_{FF}} = \lambda_{49B1} = 0.102 \times 10^{-6}$ $\lambda_{LOGIC_{FF}} = \lambda_{49B2} = 0.530 \times 10^{-6}$ $\lambda_{REDUND_{FF}} = \lambda_{49B3} = 0.242 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{DDM}}}$: $\lambda_{3D} = 0.413 \times 10^{-6}$ $\lambda_{3F} = 12.832 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{12D} = 0.070 \times 10^{-6}$ $\lambda_{12F1} = 1.209 \times 10^{-6}$ $\lambda_{13A} = 0.509 \times 10^{-6}$ ——— $\lambda_{XMTR_{CSE_{DDM}}} = 16.325 \times 10^{-6}$	Note: The failure rate for $\lambda_{MON_{CSE}}$ is worst case since no discrimination is made with regards to RF, SDM, and DDM alarms. The failure rate for $\lambda_{MON_{FF}}$ is worst case also. Worst case failure rates are again used for $\lambda_{XMTR_{CSE_{DDM}}}$. All possible failure mode failure rates have been included which can produce a Cat. III course position DDM out of tolerance condition. In many instances, other parameters will also be effected by these failures. Hence, a worst case analysis results. It is noteworthy to mention that to calculate precisely this overall probability is virtually impossible. However, the calculation is extremely simplified by a worst case analysis. A weekly monitor and control logic preventive maintenance cycle is assumed to check for hidden failures which result in a loss of monitoring ability.

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous course position Cat. III DDM signal due to equipment failure. (continued)	$P_{XMTR_{CSE_{DDM}}} =$ The probability that an actual hazardous Cat. III course DDM will be radiated, with no other parameters being effected. $P_{INT_{CSE_{DDM}}} = 8.200 \times 10^{-7}$ $+ 1.301 \times 10^{-14}$ $+ 0.247 \times 10^{-7}$ $= 8.447 \times 10^{-7}$ $P_{MON_{FF}} = 5.519 \times 10^{-7}$ $+ 5.032 \times 10^{-15}$ $+ 0.036 \times 10^{-7}$ $= 5.555 \times 10^{-7}$ $P_{XMTR_{CSE_{DDM}}} = 2.743 \times 10^{-3}$ $P(HS)_{CSE_{DDM}} = 1.287 \times 10^{-15}$		
Probability of the radiation of a hazardous signal that is out of Cat. III course position tolerance at the far field only.	$P(HS)_{FF} - P_{MON_{FF}} \cdot P_{FF_{CSE_{DDM}}}$ $P_{MON_{FF}} = (\lambda_{MON_{FF}} \cdot 168)^2$ $+ (\lambda_{GATE_{FF}} \cdot 168)^3$ $+ [(\lambda_{LOGIC_{FF}} \cdot 168)$ $\times (\lambda_{REDUND_{FF}} \cdot 168)]$	$\lambda_{MON_{FF}} = \lambda_{56C} = \lambda_{57C}$ $= \lambda_{58C} = 4.422 \times 10^{-6}$ $\lambda_{GATE_{FF}} = \lambda_{49B1} = 0.102 \times 10^{-6}$ $\lambda_{LOGIC_{FF}} = \lambda_{49B2} = 0.530 \times 10^{-6}$ $\lambda_{REDUND_{FF}} = \lambda_{49B3} = 0.242 \times 10^{-6}$	For the probability $P_{FF_{CSE_{DDM}}}$, some number must be assumed since *this number is unpredictable*, being a function of runway activity. For convenience, let $P_{FF_{CSE_{DDM}}} = 10^{-3}$

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous signal that is out of Cat. III course position tolerance at the far field only. (continued)	$P_{MON_{FF}} =$ The probability of a hidden failure in the far field Cat. III DDM monitoring circuitry. $P_{MON_{FF}} = 5.555 \times 10^{-7}$ $P_{FF_{CSE_{DDM}}} =$ The probability that the ILS signal will be out of Cat. III DDM tolerance at the far field due to external runway disturbances during the critical landing phase of a Cat. III landing. $P(HS)_{FF} = 5.555 \times 10^{-10}$		
Probability of the radiation of a hazardous course position Cat. III SDM signal, i.e., incorrect percentage modulation.	$P(HS)_{CSE_{SDM}} = P_{INT_{CSE_{SDM}}} \times P_{XMTR_{CSE_{SDM}}}$ $P_{INT_{CSE_{SDM}}} = (\lambda_{MON_{CSE}} \cdot 168)^2 + (\lambda_{GATE} \cdot 168)^3 + [(\lambda_{LOGIC} \cdot 168) \times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CSE_{SDM}}} = (\lambda_{XMTR_{CSE_{DDM}}} \cdot 168)$	$\lambda_{MON_{CSE}} = \lambda_{35B} = \lambda_{36B} = \lambda_{37B} = 5.390 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{ID1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{ID2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{ID3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{SDM}}}$: $\lambda_{3B} = 0.413 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{12D} = 0.070 \times 10^{-6}$ $\lambda_{12F1} = 1.209 \times 10^{-6}$ $\lambda_{13A} = 0.509 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{SDM}}} = 3.503 \times 10^{-6}$	Note: Since the processing for any parameter is virtually identical in the control unit, the same failure rates for λ_{GATE}, λ_{LOGIC} and λ_{REDUND} are utilized. By employing $\lambda_{MON_{CSE}}$ in the calculation of $P_{INT_{CSE_{SDM}}}$, a worst case analysis again results.

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous course position Cat. III SDM signal, i.e., incorrect percentage modulation. (continued)	$P_{INT_{CSE_{SDM}}}$ = The probability of a failure of the course Cat. III SDM integral monitoring circuitry. (hidden) $P_{XMTR_{CSE_{SDM}}}$ The probability that an actual hazardous Cat. III SDM will be radiated, with no other parameters effected. $P_{INT_{CSE_{SDM}}} = P_{INT_{CSE_{DDM}}} = 8.447 \times 10^{-7}$ $P_{XMTR_{CSE_{SDM}}} = 5.885 \times 10^{-4}$ $P(HS)_{CSE_{SDM}} = 4.971 \times 10^{-10}$		
Probability of the radiation of a signal that is out of Cat. III limit with respect to course RF power.	$P(HS)_{CSE_{RF}} = P_{INT_{CSE_{RF}}} \times P_{XMTR_{CSE_{RF}}}$ $P_{INT_{CSE_{RF}}} = (\lambda_{MON_{CSE}} \cdot 168)^2 + (\lambda_{GATE} \cdot 168)^3 + [(\lambda_{LOGIC} \cdot 168) \times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CSE_{RF}}} = (\lambda_{XMTR_{CSE_{RF}}} \cdot 168)$	Utilization of $\lambda_{MON_{CSE}}$ is general and worst case; hence, $P_{INT_{CSE_{RF}}} = P_{INT_{CSE_{DDM}}} = P_{INT_{CSE_{SDM}}}$ $\lambda_{XMTR_{CSE_{RF}}}$: $\lambda_{2B} = 7.150 \times 10^{-6}$ $\lambda_{3B} = 0.413 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{12F1} = 1.209 \times 10^{-6}$ $\lambda_{13A} = 0.509 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{RF}}} = 10.583 \times 10^{-6}$	Worst case analysis performed.

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a signal that is out of Cat. III limit with respect to course RF power. (continued)	$P_{INT_{CSE_{RF}}}$ = The probability of a failure of the course Cat. III RF integral monitoring circuitry. (hidden) $P_{XMTR_{CSE_{RF}}}$ = The probability that an actual hazardous signal outside of Cat. III power limit will be radiated, with no other parameters effected. $P_{INT_{CSE_{RF}}} = P_{INT_{CSE_{DDM}}}$ $= 8.447 \times 10^{-7}$ $P_{XMTR_{CSE_{RF}}} = 1.778 \times 10^{-3}$ $P(HS)_{CSE_{RF}} = 1.502 \times 10^{-9}$		
Probability of the radiation of a signal that is out of Cat. III limit with respect to course width-sensitivity DDM.	$P(HS)_{SEN} = P_{INT_{SEN}} \cdot P_{XMTR_{SEN}}$ $P_{INT_{SEN}} = (\lambda_{MON_{SEN}} \cdot 168)^2$ $+ (\lambda_{GATE} \cdot 168)^3$ $+ [(\lambda_{LOGIC} \cdot 168)$ $\cdot (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{SEN}} = (\lambda_{XMTR_{SEN}} \cdot 168)$	$\lambda_{MON_{SEN}} = \lambda_{38B} = \lambda_{39B}$ $= \lambda_{40B} = 2.892 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{ID1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{ID2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{ID3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{SEN}}$: $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{12D} = 0.070 \times 10^{-6}$ $\lambda_{12\Gamma1} = 1.209 \times 10^{-6}$ $\lambda_{13A} = 0.509 \times 10^{-6}$ $\lambda_{XMTR_{SEN}} = 3.090 \times 10^{-6}$	Worst case analysis performed.

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a signal that is out of Cat. III limit with respect to course width-sensitivity DDM. (continued)	$P_{INT_{SEN}}$ = The probability of a failure of the sensitivity Cat. III DDM integral monitoring circuitry. (hidden) $P_{XMTR_{SEN}}$ = The probability that a signal that is out of Cat. III tolerance for course width be radiated, with no other parameters effected. $P_{INT_{SEN}} = 2.361 \times 10^{-7} + 1.301 \times 10^{-14} + 0.247 \times 10^{-7} = 2.608 \times 10^{-7}$ $P_{XMTR_{SEN}} = 5.191 \times 10^{-4}$ $P(HS)_{SEN} = 1.354 \times 10^{-10}$		
Probability of the radiation of a hazardous signal that is out of clearance Cat. III DDM tolerance.	$P(HS)_{CL_{DDM}} = P_{INT_{CL_{DDM}}} \cdot P_{XMTR_{CL_{DDM}}}$ $P_{INT_{CL_{DDM}}} = (\lambda_{MON_{CL}} \cdot 168)^2 + (\lambda_{GATE} \cdot 168)^3 + [(\lambda_{LOGIC} \cdot 168) \times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CL_{DDM}}} = (\lambda_{XMTR_{CL_{DDM}}} \cdot 168)$	$\lambda_{MON_{CL}} = \lambda_{43B} = \lambda_{44B} = \lambda_{45B} = 5.551 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{ID1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{ID2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{ID3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{CL_{DDM}}}$: $\lambda_{4A} = 1.446 \times 10^{-6}$ $\lambda_{4B} = 7.150 \times 10^{-6}$ $\lambda_{5} = 10.250 \times 10^{-6}$ $\lambda_{3H} = 1.552 \times 10^{-6}$ $\lambda_{3I} = 0.388 \times 10^{-6}$ $\lambda_{3J} = 0.756 \times 10^{-6}$	As in the case of the course parameters, a general failure rate ($\lambda_{MON_{CL}}$) of the hidden failures within the clearance monitor channels will be utilized, leading to a worst case analysis. Note: Probabilities of the radiation of a hazardous signal that is out of clearance Cat. III SDM or RF tolerances are virtually zero. This is due to the fact that any change in the percentage of modulation or RF power simultaneously effect the clearance DDM. No isolated failure rates for these two parameters exists.

Table E-1. Localizer Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous signal that is out of clearance Cat. III DDM tolerance. (continued)	$P_{INT_{CL_{DDM}}}$ = The probability of failure of the clearance Cat. III DDM integral monitoring circuitry. (hidden) $P_{XMTR_{CL_{DDM}}}$ = The probability that the radiation of the clearance signal will be out of Cat. III tolerance for DDM, with no other parameters effected. $P_{INT_{CL_{DDM}}} = 8.697 \times 10^{-7}$ $+ 1.301 \times 10^{-14}$ $+ 0.247 \times 10^{-7}$ $= 8.944 \times 10^{-7}$ $P_{XMTR_{CL_{DDM}}} = 4.007 \times 10^{-3}$ $P(HS)_{CL_{DDM}} = 3.584 \times 10^{-9}$	$\lambda_{12F1} = 1.209 \times 10\text{-}6$ $\lambda_{12E} = 0.070 \times 10^{-6}$ $\lambda_{14A} = 1.032 \times 10^{-6}$ $\lambda_{XMTR_{CL_{DDM}}} = 23.853 \times 10^{-6}$	

Table E-2. Localizer Shutdown Probabilities

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Single failures in the localizer equipment that cause immediate localizer shutdown.	$P_S = \Sigma\lambda_{\text{Single Failures}} \div 10\text{ SEC}$ $P_S = (14.083 \times 10^{-6} \times 10\text{ SEC})$ $P_S = (14.083 \times 10^{-6}) \times 10/3600$ $P_S = 3.912 \times 10^{-8}$	$\lambda_{1A} = 1.827 \times 10^{-6}$ $\lambda_{1B} = 3.507 \times 10^{-6}$ $\lambda_{1O} = 0.140 \times 10^{-6}$ $\lambda_{1Z} = 0.339 \times 10^{-6}$ $\lambda_{1AA} = 1.506 \times 10^{-6}$ $\lambda_{12F} = 2.417 \times 10^{-6}$ $\lambda_{13} = 0.859 \times 10^{-6}$ $\lambda_{14A} = 1.032 \times 10^{-6}$ $\lambda_{14B} = 0.040 \times 10^{-6}$ $\lambda_{34F} = 0.137 \times 10^{-6}$ $\lambda_{34G} = 0.290 \times 10^{-6}$ $\lambda_{34H} = 0.262 \times 10^{-6}$ $\lambda_{49C} = 0.512 \times 10^{-6}$ $\lambda_{49E} = 0.525 \times 10^{-6}$ $\lambda_{49M} = 0.690 \times 10^{-6}$ $\Sigma\lambda = 14.083 \times 10^{-6}$ (Failures per million hours)	The subscript on λ refers to the failure mode; hence, failure rate identification is readily accomplished.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure in the main transmitting unit and a failure in the standby transmitting unit. Both failures occur within the critical phase of the Cat. III landing (10 seconds) and it is immaterial of which failure occurs first.	$P_{AB} = P_A \cdot P_B$ P_A = The probability of loss of the main transmitting unit. P_B = The probability of loss of the standby transmitting unit. $P_{AB} = (\lambda_A \cdot 10\ SEC)(\lambda_B \cdot 10\ SEC)$ $P_{AB} = 7.626 \times 10^{-6} \cdot 10\ SEC$ $\times (67.346 \times 10^{-6}$ $\cdot 10\ SEC)$ P_A: (1.879×10^{-7}) $\times (1.871 \times 10^{-7}$ $= 3.516 \times 10^{-14}$	λ_A: $\lambda_{2A} = 1.446 \times 10^{-6}$ $\lambda_{2B} = 7.150 \times 10^{-6}$ $\lambda_{4A} = 1.446 \times 10^{-6}$ $\lambda_{4B} = 7.150 \times 10^{-6}$ $\lambda_5 = 10.250 \times 10^{-6}$ $\lambda_{3A} = 2.413 \times 10^{-6}$ $\lambda_{3B} = 0.413 \times 10^{-6}$ $\lambda_{3C} = 1.453 \times 10^{-6}$ $\lambda_{3F} = 12.832 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{3H} = 1.552 \times 10^{-6}$ $\lambda_{3I} = 0.388 \times 10^{-6}$ $\lambda_{3J} = 0.756 \times 10^{-6}$ $\lambda_{6A} = 3.949 \times 10^{-6}$ $\lambda_{6B} = 13.134 \times 10^{-6}$ $\lambda_{1M} = 0.420 \times 10^{-6}$ $\lambda_{1R} = 0.960 \times 10^{-6}$ $\lambda_{1BB1} = 0.338 \times 10^{-6}$ $\lambda_{12B} = 0.134 \times 10^{-6}$ $\lambda_{12D} = 0.070 \times 10^{-6}$ $\lambda_{12E} = 0.070 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Any failure mode of λ_A with any other failure mode of λ_B will shut down the localizer station. Note that all failure modes considered in λ_A and λ_B are free of hidden failures; hence, the 10 second time interval for probability calculations is common to all failure modes.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
		λ_B: $\lambda_{7A} = 1.446 \times 10^{-6}$ $\lambda_{7B} = 7.150 \times 10^{-6}$ $\lambda_{9A} = 1.446 \times 10^{-6}$ $\lambda_{9B} = 7.150 \times 10^{-6}$ $\lambda_{10} = 10.250 \times 10^{-6}$ $\lambda_{8A} = 2.413 \times 10^{-6}$ $\lambda_{8B} = 0.413 \times 10^{-6}$ $\lambda_{8C} = 1.453 \times 10^{-6}$ $\lambda_{8F} = 12.832 \times 10^{-6}$ $\lambda_{8G} = 1.302 \times 10^{-6}$ $\lambda_{8H} = 1.552 \times 10^{-6}$ $\lambda_{8I} = 0.388 \times 10^{-6}$ $\lambda_{8J} = 0.756 \times 10^{-6}$ $\lambda_{11A} = 3.949 \times 10^{-6}$ $\lambda_{11B} = 13.134 \times 10^{-6}$ $\lambda_{1N} = 0.280 \times 10^{-6}$ $\lambda_{1R} = 0.960 \times 10^{-6}$ $\lambda_{1BB2} = 0.338 \times 10^{-6}$ $\lambda_{12B} = 0.134 \times 10^{-6}$ $\lambda_B = 67.346 \times 10^{-6}$	

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
A hidden failure in the equipment which essentially inhibits the transfer capability of the transmitting units and then a failure in the main transmitting unit.	$P_{AC} = \frac{\lambda_C}{\lambda_A + \lambda_C} \quad (P_A \cdot P_C)$ P_A = Previously identified. P_C = The probability of the loss of the transfer to standby capability. $P_A = 1.879 \times 10^{-7}$ $P_C = (\lambda_C \quad 2\ WK)$ $= (\lambda_C \cdot 336\ HR)$ $= 1.251 \times 10^{-3}$ $P_{AC} = 1.227 \times 10^{-11}$	λ_C: $\lambda_{1Q} = 0.844 \times 10^{-6}$ $\lambda_{1T} = 2.658 \times 10^{-6}$ $\lambda_{12A} = 0.221 \times 10^{-6}$ $\lambda_C = 3.723 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	The factor $\left(\frac{\lambda_C}{\lambda_A + \lambda_C}\right)$ is the conditional probability that the hidden failure modes (λ_C) will occur prior to a main transmitting unit failure that initiates a transfer (λ_A). A two week preventive maintenance cycle is assumed to check the transfer capability of the localizer station.
A failure in the standby monitoring system initiating a shutdown of the standby transmitting unit and then a failure in the main transmitting unit.	$P_{AD} = \frac{\lambda_D}{\lambda_A + \lambda_D} \quad (P_A \cdot P_D)$ P_A = Previously identified. P_D = The probability of the loss of the standby transmitting unit due to a failure in the standby monitoring. $P_A = 1.879 \times 10^{-7}$ $P_D = \lambda_D \cdot 10\ SEC$ $P_D = 1.237 \times 10^{-7}$ $P_{AD} = 9.226 \times 10^{-13}$	λ_D: $\lambda_{12C} = 0.782 \times 10^{-6}$ $\lambda_{46A} = 13.310 \times 10^{-6}$ $\lambda_{47A} = 9.367 \times 10^{-6}$ $\lambda_{48A} = 14.280 \times 10^{-6}$ $\lambda_{11} = 1.164 \times 10^{-6}$ $\lambda_{31A} = 0.789 \times 10^{-6}$ $\lambda_{31B} = 0.386 \times 10^{-6}$ $\lambda_{32A} = 0.789 \times 10^{-6}$ $\lambda_{32B} = 0.386 \times 10^{-6}$ $\lambda_{33A} = 0.789 \times 10^{-6}$ $\lambda_{33B} = 0.386 \times 10^{-6}$ $\lambda_{34C} = 1.914 \times 10^{-6}$ $\lambda_{34J} = 0.172 \times 10^{-6}$ $\lambda_D = 44.514 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	The factor $\left(\frac{\lambda_D}{\lambda_A + \lambda_D}\right)$ is the conditional probability that a failure of λ_D will occur prior to a failure of λ_A. Note that after a failure in the main transmitting unit has occurred and a transfer accomplished, standby monitoring is meaningless.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for $P_{STBY_{CSE}}$: (1) Loss of monitoring ability of the standby course monitor. (2) Failure causing the generation of a faulty course DDM, SDM, or RF parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{CSE}} = \left(\frac{\lambda_{46B}}{\lambda_{46B} + \lambda_{ABCD}}\right) \cdot P_{46B}$ $\times \left(\frac{\lambda_{B_{CSE}}}{\lambda_A + \lambda_{B_{CSE}}}\right) \cdot P_{B_{CSE}}$ $\times P_A$ P_{46B} = Probability of sequence (1). $P_{B_{CSE}}$ = Probability of sequence (2). P_A = Probability of sequence (3), previously identified. $P_{46B} = (\lambda_{46B} \cdot 336\ HR)$ $P_{B_{CSE}} = (\lambda_{B_{CSE}} \cdot 336\ HR)$ = $P_A = 1.879 \times 10^{-7}$ $P_{STBY_{CSE}} = (5.176 \times 10^{-5})$ $\times (1.771 \times 10^{-3})$ $\times (1.879 \times 10^{-7})$ $P_{STBY_{CSE}} = 1.722 \times 10^{-14}$	$\lambda_{46B} = 5.390 \cdot 10^{-6}$ λ_{ABCD}: $\lambda_A = 67.626 \times 10^{-6}$ $\lambda_B = 67.346 \times 10^{-6}$ $\lambda_C = 3.723 \times 10^{-6}$ $\lambda_D = 44.514 \times 10^{-6}$ $\lambda_{ABCD} = 183.209 \times 10^{-6}$ $\lambda_{B_{CSE}}$: $\lambda_{7B} = 7.150 \times 10^{-6}$ $\lambda_{8B} = 0.413 \times 10^{-6}$ $\lambda_{8F} = 12.832 \times 10^{-6}$ $\lambda_{8G} = 1.302 \times 10^{-6}$ $\lambda_{B_{CSE}} = 21.697 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Factors $\left(\frac{\lambda_{46B}}{\lambda_{46B} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_{B_{CSE}}}{\lambda_A + \lambda_{B_{CSE}}}\right)$ are conditional probabilities that compensate for sequence ordering of P_{46B} and $P_{B_{CSE}}$ respectively. Note that worst case failure rate for $\lambda_{B_{CSE}}$ has been used since some of the failure rate of $\lambda_{B_{CSE}}$ may also produce a sensitivity Cat. III DDM alarm. Also no discrimination has been made as to which course parameter (DDM, SDM, or RF) is faulty. Hence, the entire probability calculation is worst case.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for $P_{STBY_{SEN}}$: (1) Loss of monitoring ability of the standby sensitivity monitor. (2) Failure causing the generation of a faulty course width (DDM) parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{SEN}} = \left(\frac{\lambda_{47B}}{\lambda_{47B} + \lambda_{ABCD}}\right) \cdot P_{47B}$ $\times \left(\frac{\lambda_{B_{SEN}}}{\lambda_A + \lambda_{B_{SEN}}}\right) \cdot P_{B_{SEN}}$ $\times P_A$ P_{47B} Probability of sequence (1) $P_{B_{SEN}}$ Probability of sequence (2) $P_A = 1.879 \times 10^{-7}$ $P_{47B} = (\lambda_{47B} \cdot 336\ HR)$ $P_{B_{SEN}} = (\lambda_{B_{SEN}} \cdot 336\ HR)$ $P_{STBY_{SEN}} = (1.510 \times 10^{-5})$ $\times (1.051 \times 10^{-3})$ $\times (1.879 \times 10^{-7})$ $P_{STBY_{SEN}} = 2.982 \times 10^{-15}$	$\lambda_{47B} = 2.892 \times 10^{-6}$ $\lambda_{ABCD} = 183.209 \times 10^{-6}$ (previously identified) $\lambda_{B_{SEN}}$: $\lambda_{8B} = 0.413 \times 10^{-6}$ $\lambda_{8F} = 12.832 \times 10^{-6}$ $\lambda_{86} = 1.302 \times 10^{-6}$ $\lambda_{B_{SEN}} = 14.547 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Factors $\left(\frac{\lambda_{47B}}{\lambda_{47B} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_{B_{SEN}}}{\lambda_A + \lambda_{B_{SEN}}}\right)$ are conditional probabilities that compensate for sequence ordering of P_{47B} and $P_{B_{SEN}}$ respectively. Note that worst case failure rate for $\lambda_{B_{SEN}}$ has been used. Some of the failure rate of $\lambda_{B_{SEN}}$ may also produce Cat. III course monitor alarm, thus leading to a worst case $P_{STBY_{SEN}}$ probability calculation.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for $P_{STBY_{CL}}$: (1) Loss of monitoring ability of the standby clearance monitor. (2) Failure causing the generation of a faulty clearance DDM, SDM, or RF parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{CL}} = \left(\frac{\lambda_{48B}}{\lambda_{48B} + \lambda_{ABCD}}\right) \cdot P_{48B}$ $\times \left(\frac{\lambda_{B_{CL}}}{\lambda_A + \lambda_{B_{CL}}}\right) \cdot P_{B_{CL}}$ $\times P_A$ P_{48B} = Probability of sequence (1) $P_{B_{CL}}$ = Probability of sequence (2) $P_A = 1.879 \times 10^{-7}$ $P_{48B} = (\lambda_{48B} \cdot 336\ HR)$ $P_{B_{CL}} = (\lambda_{B_{CL}} \cdot 336\ HR)$ $P_{STBY_{CL}} = 5.485 \times 10^{-5}$ $\times (1.749 \times 10^{-3}$ $\times (1.879 \times 10^{-7})$ $P_{STBY_{CL}} = 1.802 \times 10^{-14}$	$\lambda_{48B} = 5.551 \times 10^{-6}$ $\lambda_{ABCD} = 183.209 \times 10^{-6}$ $\lambda_{B_{CL}}$: $\lambda_{9A} = 1.446 \times 10^{-6}$ $\lambda_{9B} = 7.150 \times 10^{-6}$ $\lambda_{10} = 10.250 \times 10^{-6}$ $\lambda_{8H} = 1.552 \times 10^{-6}$ $\lambda_{8I} = 0.388 \times 10^{-6}$ $\lambda_{8J} = 0.756 \times 10^{-6}$ $\lambda_{B_{CL}} = 21.542 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Factors $\left(\frac{\lambda_{48B}}{\lambda_{48B} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_{B_{CL}}}{\lambda_A + \lambda_{B_{CL}}}\right)$ are conditional probabilities that compensate for sequence ordering of P_{48B} and $P_{B_{CL}}$ respectively. A worst case probability calculation is made since the failure rate λ_{48B} is nondiscriminatory as to which clearance parameter (DDM, SDM, or RF) is faulty.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for $P_{STBY_{ID}}$: (1) Loss of the monitoring ability of the standby I.D. monitor. (2) Failure causing the generation of a faulty I.D. signal (or loss) of the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{ID}} \left(\frac{\lambda_{34D} + \lambda_{34K}}{\lambda_{34D} + \lambda_{34K} + \lambda_{ABCD}}\right)$ $\times \left(P_{34D} + P_{34K}\right)$ $\times \left(\frac{\lambda_{B_{ID}}}{\lambda_A + \lambda_{B_{ID}}}\right) \cdot P_{B_{ID}}$ $\times P_A$ $\left(P_{34D} + P_{34K}\right) =$ Probability of sequence (1). $P_{B_{ID}} =$ Probability of sequence. $P_{34D} = \left(\lambda_{34D} \cdot 336\ HR\right)$ $P_{34K} = \left(\lambda_{34K} \cdot 336\ HR\right)$ $P_{B_{ID}} = \left(\lambda_{B_{ID}} \cdot 336\ HR\right)$ $P_A = 1.879 \times 10^{-7}$ $P_{STBY_{ID}} = 6.407 \times 10^{-7}$ $\times 1.382 \times 10^{-3}$ $\times 1.879 \times 10^{-7}$ $P_{STBY_{ID}} = 1.665 \times 10^{-16}$	$\lambda_{34D} = 0.350 \times 10^{-6}$ $\lambda_{34K} = 0.242 \times 10^{-6}$ $\lambda_{ABCD} = 183.209 \times 10^{-6}$ $\lambda_{B_{ID}}: \lambda_{7A} = 1.446 \times 10^{-6}$ $\lambda_{11A} = 3.949 \times 10^{-6}$ $\lambda_{11B} = 13.134 \times 10^{-6}$ $\lambda_{1BB2} = 0.338 \times 10^{-6}$ $\lambda_{B_{ID}} = 18.867 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Factors $\left(\frac{\lambda_{34D} + \lambda_{34K}}{\lambda_{34D} + \lambda_{34K} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_{B_{ID}}}{\lambda_{B_{ID}} + \lambda_A}\right)$ are conditional probabilities that compensate for sequence ordering of $\left(P_{34D} + P_{34K}\right)$ and $P_{B_{ID}}$ respectively.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for P_{STBY}: (1) Loss of <u>all</u> standby monitoring ability. (2) Failure causing the generation of any faulty parameter of the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY} = \left(\frac{\lambda_{1H} + \lambda_{1SI}}{\lambda_{1H} + \lambda_{1SI} + \lambda_{ABCD}}\right)$ $\times \left(P_{1H} + P_{1SI}\right)$ $\times \left(\frac{\lambda_B}{\lambda_A + \lambda_B}\right) \cdot$ $\times \left(\lambda_B \cdot 336\ HR\right)$ $\times P_A$ $\left(P_{1H} + P_{1SI}\right) =$ Probability of sequence (1). $\left(\lambda_B \cdot 336\ HR\right) =$ Probability of sequence (2). $P_{1H} = \left(\lambda_{1H} \cdot 336\right)$ $P_{1SI} = \left(\lambda_{1SI} \cdot 336\right)$ $P_A = 1.879 \times 10^{-7}$ $P_{STBY} = \left(4.637 \times 10^{-6}\right)$ $\times \left(1.129 \times 10^{-2}\right)$ $\times \left(1.879 \times 10^{-7}\right)$ $P_{STBY} = 9.837 \times 10^{-15}$	$\lambda_{1H} = 1.399 \times 10^{-6}$ $\lambda_{1SI} = 0.198 \times 10^{-6}$ $\lambda_{ABCD} = 183.209 \times 10^{-6}$ $\lambda_B = 67.346 \times 10^{-6}$ $\lambda_A = 67.626 \times 10^{-6}$	Factors $\left(\frac{\lambda_{1H} + \lambda_{1SI}}{\lambda_{1H} + \lambda_{1SI} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_B}{\lambda_A + \lambda_B}\right)$ are conditional probabilities that compensate for sequence ordering of $\left(P_{1H} + P_{1SI}\right)$ and $\left(\lambda_B \cdot 336\ HR\right)$ respectively. Note that the probability $(\lambda_B \cdot 336HR)$ must be used rather than P_B because a two week period of failure (preventive maintenance cycle) must be used rather than the 10 second critical landing phase period.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Power supply/converter failures leading to a shutdown.	$P_{PS/CONV} = P_{CONV_{MAIN}} + P_{CONV_{FF}} + P_{PS_{FF}}$ $P_{CONV_{MAIN}}$ Probability of both main converters failing. $P_{CONV_{FF}}$ Probability of both far field monitor converters failing. $P_{PS_{FF}}$ Probability of the main power of the far field monitor failing. $P_{CONV_{MAIN}} = (\lambda_{17} \times 3\ HR) \times (\lambda_{18} \times 10\ SEC) = 3.628 \times 10^{-13}$ $P_{CONV_{FF}} = (\lambda_{51A} \times 3\ HR) \times (\lambda_{52A} \times 10\ SEC) = 4.848 \times 10^{-14}$ $P_{PS_{FF}} = (\lambda_{50B} + \lambda_{BATT_{FF}}) \times (720\ HR) \times (\lambda_{50A} \times 10\ SEC) = 9.865 \times 10^{-11}$ $P_{PS/CONV} = 9.906 \times 10^{-11}$	$\lambda_{17} = \lambda_{18} = 6.598 \times 10^{-6}$ $\lambda_{51A} = \lambda_{52A} = 2.412 \times 10^{-6}$ $\lambda_{50A} = 5.790 \times 10^{-6}$ $\lambda_{50B} = 0.519 \times 10^{-6}$ $\lambda_{BATT_{FF}} = 8.0 \times 10^{-6}$ (assumed)	Note that since a power/environmental alarm will be produced if one of the converters fails, a downgrade from Cat. III performance will occur within 3 hours; hence a 3 hour time interval is used. A monthly preventive maintenance cycle is assumed to check that the far field monitor battery and battery disconnect circuit.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Two of the three course/I.D. monitors (including respective peak detectors) failing, producing an alarm.	$P_{CSE/ID} = (\lambda_{CSE/ID} \cdot 336\ HRS) \times (2 \cdot \lambda_{CSE/ID} \cdot 10\ SEC)$ $= (5.557 \times 10^{-3}) \times (9.188 \times 10^{-8})$ $= 5.106 \times 10^{-10}$ Note: If each monitor were considered separately, the probability of failure of each of the 3 monitors is 1/3 of the above: $P_{CSE/ID1} = \left(\frac{\lambda_{CSE/ID_1}}{\lambda_{CSE/ID_1} + \lambda_{CSE/ID_2} + \lambda_{CSE/ID_3}}\right)$ $\times (\lambda_{CSE/ID_1} \cdot 336\ HR)$ $+ \left[(\lambda_{CSE/ID_2} + \lambda_{CSE/ID_3}) \cdot \times 10\ SEC\right]$ $= 1/3 \cdot (\lambda_{CSE/ID} \cdot 336\ HR)$ $+ (2 \cdot \lambda_{CSE/ID} \cdot 10\ SEC)$	$\lambda_{CSF/ID}$: $\lambda_{CSE/ID} = \lambda_{CSE/ID_1} = \lambda_{CSE/ID_2} = \lambda_{CSE/ID_3}$ λ_{CSE/ID_1}: $\lambda_{35A} = 13.310 \times 10^{-6}$ $\lambda_{20A} = 0.789 \times 10^{-6}$ $\lambda_{20B} = 0.386 \times 10^{-6}$ $\lambda_{34A1} = 1.914 \times 10^{-6}$ $1/3\lambda_{1C1} = 0.140 \times 10^{-6}$ $\lambda_{CSE/ID_1} = 16.539 \times 10^{-6}$ $\lambda_{CSE/ID_2} = \lambda_{36A} + \lambda_{21A} + \lambda_{21B} + \lambda_{34A2} + 1/3\lambda_{1C1}$ $= 16.539 \times 10^{-6}$ $\lambda_{CSE/ID_3} = \lambda_{37A} + \lambda_{22A} + \lambda_{22B} + \lambda_{34A3} + 1/3\lambda_{1C1}$ $= 16.539 \times 10^{-6}$	It should be noted that since an output from the course monitor channel feeds the respective I.D. monitor channel, a worst case analysis may be accomplished by treating both on an aggregate basis. Furthermore, no discrimination is made among the course RF, SDM, and DDM alarms-again leading to worst case analysis. Note that it is assumed maintenance action will be employed within 2 weeks (336 HR) after a monitor abnormal due to a monitor mismatch occurs.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Two of the sensitivity monitors/ peak detectors failing, producing an alarm.	P_{SEN} $\lambda_{SEN} \cdot 336$ HR $+ 2 \cdot \lambda_{SEN} \cdot 10$ SEC $= 2.090 \times 10^{-10}$	$\lambda_{SEN} = \lambda_{SEN_1} = \lambda_{SEN_2} = \lambda_{SEN_3}$ λ_{SEN_1}: $\lambda_{38A} = 9.367 \times 10^{-6}$ $\lambda_{23A} = 0.789 \times 10^{-6}$ $\lambda_{23B} = 0.386 \times 10^{-6}$ $1/3\lambda_{1C2} = 0.047 \times 10^{-6}$ $\lambda_{SEN_1} = 10.589 \times 10^{-6}$ $\lambda_{SEN_2} = \lambda_{39A} + \lambda_{24A} + \lambda_{24B} + 1/3\lambda_{1C2}$ $= 10.589 \times 10^{-6}$ $\lambda_{SEN_3} = \lambda_{40A} + \lambda_{25A} + \lambda_{25B} + 1/3\lambda_{1C2}$ $= 10.589 \times 10^{-6}$	

Table E-2. Localizer Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Two of the clearance monitors/ peak detectors failing, producing an alarm.	$P_{CL} = (\lambda_{CL} \cdot 336\ HR)$ $\times (2 \cdot \lambda_{CL} \cdot 10\ SEC)$ $= 4.540 \times 10^{-10}$	$\lambda_{CL} = \lambda_{CL_1} = \lambda_{CL_2} = \lambda_{CL_3}$ λ_{CL_1}: $\lambda_{43A} = 14.280 \times 10^{-6}$ $\lambda_{26A} = 0.789 \times 10^{-6}$ $\lambda_{26B} = 0.386 \times 10^{-6}$ $1/3\lambda_{1C4} = 0.140 \times 10^{-6}$ $\lambda_{CL_1} = 15.595 \times 10^{-6}$ $\lambda_{CL_2} = \lambda_{44A} + \lambda_{27A}$ $+ \lambda_{27B} + 1/3\lambda_{1C4}$ $= 15.595 \times 10^{-6}$ $\lambda_{CL_3} = \lambda_{45A} + \lambda_{28A}$ $+ \lambda_{28B} + 1/3\lambda_{1C4}$ $= 15.595 \times 10^{-6}$	Worst case analysis is again considered since no discrimination has been made among the clearance DDM, SDM, or RF alarms.

Table E-2. Localizer Shutdown Probabilities (Cont'd)

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Probability Description	Probability Calculation	Failure Rate Data	Remarks
Both of the near field monitors/ peak detectors failing, producing an alarm.	$P_{NF} = (\lambda_{NF} \cdot 336\ HR)$ $\times (\lambda_{NF} \cdot 10\ SEC)$ $= 1.422 \times 10^{-10}$	$\lambda_{NF} = \lambda_{NF1} = \lambda_{NF2}$ λ_{NF1}: $\lambda_{41A} = 11.099 \times 10^{-6}$ $\lambda_{29A} = 0.789 \times 10^{-6}$ $\lambda_{29B} = 0.386 \times 10^{-6}$ $1/2\lambda_{1C3} = 0.070 \times 10^{-6}$ $\lambda_{NF1} = 12.344 \times 10^{-6}$ $\lambda_{NF2} = \lambda_{42A} + \lambda_{30A}$ $+ \lambda_{30B} + 1/3\lambda_{1C3}$ $= 12.$[illegible]1×10^{-6}	Note that the failure of both the DDM and SDM has been included in the near field monitor channel failure rate, since the SDM strap option for a general alarm will be utilized.
Two of the three far field monitors/ receivers failing, producing an alarm.	$P_{FF} = (\lambda_{FF} \cdot 336\ HR)$ $\times (2 \cdot \lambda_{FF} \cdot 10\ SEC)$ 6.081×10^{-10}	$\lambda_{FF} = \lambda_{FF1} = \lambda_{FF2} = \lambda_{FF3}$ λ_{FF1}: $\lambda_{56B} = 11.099 \times 10^{-6}$ $\lambda_{53} = 6.879 \times 10^{-6}$ $1/3\lambda_{49HI} = 0.071 \times 10^{-6}$ $\lambda_{FF1} = 18.049 \times 10^{-6}$ $\lambda_{FF2} = \lambda_{57B} + \lambda_{54} + 1/3\lambda_{49HI}$ $= 18.049 \times 10^{-6}$ $\lambda_{FF3} = \lambda_{58B} + \lambda_{55} + 1/3\lambda_{49HI}$	Note that the failure rate of the SDM is also included, since the SDM strap option for a general Cat. II alarm will be utilized. Although a time delay (nominal 120 seconds) exists at the far field for alarm processing, the 10 sec time interval in the probability calculation is still used. Only the initial arbitrary reference has changed.
Failure inhibiting the monitors while the ILS signal is radiated. A shutdown status will result-loss of Cat. III and Cat. II status.	$P_{INHIB} = (\lambda_{52} + \lambda_{IW}) \cdot 10\ SEC$ 6.822×10^{-9}	$\lambda_{52} = 2.316 \times 10^{-6}$ $\lambda_{IW} = 0.140 \times 10^{-6}$	

Appendix F

Glideslope Math Models

Appendix F

Glideslope Math Models

This appendix consists of tables F-1 and F-2, referred to in section 8.0, which give respectively, probability math models for glideslope hazardous signal radiation and shutdown.

Table F-1. Glideslope Hazardous Signal Radiation Probabilities

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Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous course position (path angle) Cat. III DDM signal.	$P(HS)_{CSE_{DDM}} = P_{INT_{CSE_{DDM}}}$ $\times P_{MON_{NF}}$ $\times P_{XMTR_{CSE_{DDM}}}$ $P_{INT_{CSE_{DDM}}} = (\lambda_{MON_{CSE}} \cdot 168)^2$ $+ (\lambda_{GATE} \cdot 168)^3$ $+[(\lambda_{LOGIC} \cdot 168)$ $\times (\lambda_{REDUND} \cdot 168)]$ $P_{MON_{NF}} = (\lambda_{MON_{NF}} \cdot 168)^2$ $+ (\lambda_{GATE} \cdot 168)^3$ $+ [(\lambda_{LOGIC_{NF}} \cdot 168)$ $\times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CSE_{DDM}}} = (\lambda_{XMTR_{CSE_{DDM}}}$ $\cdot 168)$ $P_{INT_{CSE_{DDM}}} =$ The probability of a hidden failure in the course Cat. III DDM integral monitoring circuitry. $P_{MON_{NF}} =$ The probability of a hidden failure in the near field Cat. III DDM monitoring circuitry.	$\lambda_{MON_{CSE}} = \lambda_{34B} = \lambda_{35B}$ $= \lambda_{36B} = 4.836 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{MON_{NF}} = \lambda_{43B} = \lambda_{44B}$ $= \lambda_{45B} = 3.822 \times 10^{-6}$ $\lambda_{LOGIC_{NF}} = \lambda_{1F} = 1.737 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{DDM}}}$: $\lambda_{3B} = 0.427 \times 10^{-6}$ $\lambda_{3F} = 12.832 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{10D} = 0.070 \times 10^{-6}$ $\lambda_{10E1} = 0.466 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{DDM}}} = 16.328 \times 10^{-6}$	The failure rate for $\lambda_{MON_{CSE}}$ is worst case since no discrimination is made with regards to RF, SDM, and DDM alarms. A weekly monitor and control logic preventive maintenance cycle is assumed to check for hidden failures which result in a loss of monitoring ability. Worst case failure rates are used for $\lambda_{XMTR_{CSE_{DDM}}}$. All possible failure mode failure rates have been included which can produce a Cat. III course position DDM cut of tolerance condition. In many instances, other parameters will also be effected by these failures.

Table F-1. Glideslope Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous course position (path angle) Cat. III DDM signal. (continued)	$P_{XMTR_{CSE_{DDM}}}$ The probability that an actual hazardous Cat. III course DDM will be radiated, while no other parameters are effected. $P_{INT_{CSE_{DDM}}} = 6.601 \times 10^{-7}$ $+ 1.301 \times 10^{-14}$ $+ 0.247 \times 10^{-7}$ $= 6.848 \times 10^{-7}$ $P_{MON_{NF}} = 4.123 \times 10^{-7}$ $+ 1.301 \times 10^{-14}$ $+ 0.612 \times 10^{-7}$ $= 4.735 \times 10^{-7}$ $P_{XMTR_{CSE_{DDM}}} = 2.743 \times 10^{-3}$ $P(HS)_{CSE_{DDM}} = 8.989 \times 10^{-16}$	$\lambda_{MON_{CSE}} = \lambda_{34B} + \lambda_{35B} + \lambda_{36B} = 4.836 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{SDM}}}$: $\lambda_{3B} = 0.427 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{10D} = 0.070 \times 10^{-6}$ $2\lambda_{10E1} = 0.932 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{SDM}}} = 3.$[illegible]$62 \times 10^{-6}$	Note: Since the processing for any parameter is virtually identical in the control unit, the same failure rates for λ_{GATE}, λ_{LOGIC} and λ_{REDUND} are utilized by employing $\lambda_{MON_{CSE}}$ in the calculation of $P_{INT_{CSE_{SDM}}}$, a worst case analysis again results.
Probability of the radiation of a hazardous course position Cat. III SDM signal signal, i.e., incorrect percentage modulation.	$P(HS)_{CSE_{SDM}} = P_{INT_{CSE_{SDM}}}$ $\times P_{XMTR_{CSE_{SDM}}}$ $P_{INT_{CSE_{SDM}}} = (\lambda_{MON_{CSE}} \cdot 168)^2$ $+ (\lambda_{GATE} \cdot 168)^3$ $+ [(\lambda_{LOGIC} \cdot 168)$ $\times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CSE_{SDM}}} = (\lambda_{XMTR_{CSE_{SDM}}}$ $\cdot 168)$ $P_{INT_{CSE_{SDM}}} =$ The probability of a hidden failure of the course Cat. III SDM integral monitoring circuitry.		

Table F-1. Glideslope Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a signal that is out of Cat. III limit with respect to course RF power.	$P(HS)_{CSE_{RF}} = P_{INT_{CSE_{RF}}} \times P_{XMTR_{CSE_{RF}}}$ $P_{INT_{CSE_{RF}}} = (\lambda_{MON_{CSE}} \cdot 168)^2 + (\lambda_{GATE} \cdot 168)^3 + [(\lambda_{LOGIC} \cdot 168) \times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CSE_{RF}}} = (\lambda_{XMTR_{CSE_{RF}}} \cdot 168)$ $P_{INT_{CSE_{RF}}} =$ The probability of a hidden failure of the course Cat. III RF integral monitoring. $P_{XMTR_{CSE_{RF}}} =$ The probability that an actual hazardous signal outside of Cat. III power limit will be radiated while no other parameters are effected. $P_{INT_{CSE_{RF}}} = 6.848 \times 10^{-7}$ $P_{XMTR_{CSE_{RF}}} = 1.822 \times 10^{-3}$ $P(HS)_{CSE_{RF}} = 1.248 \times 10^{-9}$	$\lambda_{MON_{CSE}} = \lambda_{34B} = \lambda_{35B} = \lambda_{36B} = 4.836 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{RF}}}$: $\lambda_2 = 6.734 \times 10^{-6}$ $\lambda_5 = 0.686 \times 10^{-6}$ $\lambda_{3B} = 0.427 \times 10^{-6}$ $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{10E1} = 0.466 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{XMTR_{CSE_{RF}}} = 10.846 \times 10^{-6}$	Worst case analysis performed.

Table F-1. Glideslope Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a signal that is out of Cat. III limit with respect to course angle width-sensitivity DDM.	$P(HS)_{SEN} = P_{INT_{SEN}} \cdot P_{XMTR_{SEN}}$ $P_{INT_{SEN}} = (\lambda_{MON_{SEN}} \cdot 168)^2 + (\lambda_{GATE} \cdot 168)^3 + [(\lambda_{LOGIC} \cdot 168) \times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{SEN}} = (\lambda_{XMTR_{SEN}} \cdot 168)$ $P_{INT_{SEN}}$ = The probability of a hidden failure of the sensitivity Cat. III DDM integral monitoring circuitry. $P_{XMTR_{SEN}}$ = The probability that a signal that is out of Cat. III tolerance for course angle width will be radiated while no other parameters are effected. $P_{INT_{SEN}} = 2.361 \times 10^{-7} + 1.301 \times 10^{-14} + 0.247 \times 10^{-7} = 2.608 \times 10^{-7}$ $P_{XMTR_{SEN}} = 5.821 \times 10^{-4}$ $P(HS)_{SEN} = 1.518 \times 10^{-10}$	$\lambda_{MON_{SEN}} = \lambda_{37B} = \lambda_{38B} = \lambda_{39B} = 2.892 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{SEN}}$: $\lambda_{3G} = 1.302 \times 10^{-6}$ $\lambda_{10D} = 0.070 \times 10^{-6}$ $2\lambda_{10E1} = 0.932 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{XMTR_{SEN}} = 3.465 \times 10^{-6}$	Worst case analysis performed.

Table F-1. Glideslope Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous clearance signal (DDM, SDM, or RF)	$P(HS)_{CL} = P_{INT_{CL}} \cdot P_{XMTR_{CL}}$ $P_{INT_{CL}} = (\lambda_{MON_{CL}} \cdot 168)^2$ $+ (3 \cdot \lambda_{GATE} \cdot 168)^3$ $+ [(3 \cdot \lambda_{LOGIC} \cdot 168)$ $\times (\lambda_{REDUND} \cdot 168)]$ $P_{XMTR_{CL}} = (\lambda_{XMTR_{CL}} \cdot 168)$ $P_{INT_{CL}} =$ The probability of a hidden failure of any of the clearance monitoring circuitry. $P_{XMTR_{CL}} =$ The probability that the radiation of the clearance signal be out of Cat. III tolerance with respect to DDM, SDM, or RF parameters. $P_{INT_{CL}} = 6.636 \times 10^{-7}$ $+ 3.513 \times 10^{-13}$ $+ 0.740 \times 10^{-7}$ $P_{XMTR_{CL}} = 1.935 \times 10^{-3}$ $P(HS)_{CL} = 1.427 \times 10^{-9}$	$\lambda_{MON_{CL}} = \lambda_{40B} = \lambda_{41B}$ $= \lambda_{42B} = 4.848 \times 10^{-6}$ $\lambda_{GATE} = \lambda_{1D1} = 0.140 \times 10^{-6}$ $\lambda_{LOGIC} = \lambda_{1D2} = 0.700 \times 10^{-6}$ $\lambda_{REDUND} = \lambda_{1D3} = 1.249 \times 10^{-6}$ $\lambda_{XMTR_{CL}}$: $\lambda_{4A} = 1.914 \times 10^{-6}$ $\lambda_{4B} = 6.734 \times 10^{-6}$ $\lambda_{3H} = 1.176 \times 10^{-6}$ $\lambda_{10E1} = 0.466 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{XMTR_{CL}} = 11.521 \times 10^{-6}$	Note that by considering the three clearance parameters (DDM, SDM, RF) collectively, a worst case analysis results.
Probability of the radiation of a hazardous signal, due to antenna tower misalignment.	$P(HS)_{ATM} = P_{MD} \cdot P_{TM}$ $P_{MD} = (\lambda_{MD} \cdot 168HR)$ $= 5.806 \times 10^{-4}$	λ_{MD}: $\lambda_{49B} = 2.354 \times 10^{-6}$ $\lambda_{1\Sigma} = 1.102 \times 10^{-6}$ $\lambda_{MD} = 3.456 \times 10^{-6}$	For the probability P_{TM}, some number must be assumed since this number is unpredictable, being a function of external and uncontrollable forces. For convenience, let $P_{TM} = 10^{-5}$.

Table F-1. Glideslope Hazardous Signal Radiation Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Probability of the radiation of a hazardous signal, due to antenna tower misalignment. (continued)	P_{MD} = The probability of the loss of tower alignment detection an not not producing an alarm. P_{TM} = The probability that the glideslope antenna tower will become misaligned within the preventive maintenance cycle time of one week. Note that the misalignment must effect only the path angle width (sensitivity) or clearence signal, since the course position is field monitored by the near field monitors. $P(HS) = 5.806 \times 10^{-9}$		

Table F-2. Glideslope Shutdown Probabilities

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Single failures in glideslope equipment that cause immediate glideslope shutdown.	$P_S = \Sigma\lambda_{SINGLE\ FAILURES} \cdot 5\ SEC$ $P_S = 15.815 \times 10^{-6} \times 5\ SEC$ $P_S = 2.197 \times 10^{-8}$	$\lambda_{1A} = 2.895 \times 10^{-6}$ $\lambda_{1B} = 2.004 \times 10^{-6}$ $\lambda_{1O} = 0.140 \times 10^{-6}$ $\lambda_{1Z} = 6.339 \times 10^{-6}$ $\lambda_{1AA} = 1.464 \times 10^{-6}$ $\lambda_{10E} = 1.951 \times 10^{-6}$ $\lambda_{11} = 1.231 \times 10^{-6}$ $\lambda_{12} = 0.778 \times 10^{-6}$ $\lambda_{18} = 0.098 \times 10^{-6}$ $\lambda_{49A} = 4.915 \times 10^{-6}$ $\Sigma\lambda = 15.815 \times 10^{-6}$ (failures per million hours)	The subscript on λ refers to the failure mode; hence, failure rate identification is readily accomplished. Note: The same nomenclature as for the localizer will be employed for the glideslope in specifying and determining probabilities.
Failure in the main transmitting unit and a failure in the standby transmitting unit. Both failures occur within the critical phase of the Cat. III landing (5 seconds for glideslope) and it is immaterial of which failure occurs first.	$P_{AB} = P_A \cdot P_B$ P_A = The probability of loss of the main transmitting unit. P_B = The probability of loss of the standby transmitting unit. $P_{AB} = (\lambda_A \cdot 5\ SEC)(\lambda_B \cdot 5\ SEC)$ $P_{AB} = (37.455 \times 10^{-6} \times 5\ SEC)$ $\times (37.245 \times 10^{-6} \times 5\ SEC)$ $= 2.691 \times 10^{-15}$	$\lambda_A : \lambda_2 = 6.734 \times 10^{-6}$ $\lambda_{4A} = 1.914 \times 10^{-6}$ $\lambda_{4B} = 6.734 \times 10^{-6}$ $\lambda_5 = 0.686 \times 10^{-6}$ $\lambda_{3A} = 2.613 \times 10^{-6}$ $\lambda_{3B} = 0.427 \times 10^{-6}$ $\lambda_{3C} = 1.453 \times 10^{-6}$ $\lambda_{3F} = 12.832 \times 10^{-6}$ $\lambda_{3C} = 1.302 \times 10^{-6}$ $\lambda_{3H} = 1.176 \times 10^{-6}$ $\lambda_{1M} = 0.420 \times 10^{-6}$ $\lambda_{1R} = 0.960 \times 10^{-6}$ $\lambda_{10B} = 0.134 \times 10^{-6}$ $\lambda_{10D} = 0.070 \times 10^{-6}$ $\lambda_A = 37.455 \times 10^{-6}$	Any failure mode of λ_A with any Any failure mode of λ_A with any other failure mode of λ_B will shut down the glideslope station. Note that all failure modes considered in λ_A and λ_B are free of hidden failures; hence, the 5 second time interval for probability calculations is common to all failure modes.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure in the main transmitting unit and a failure in the standby transmitting unit. Both failures occur within the critical phase of the Cat. III landing (5 seconds for glideslope) and it is immaterial of which failure occurs first. (continued)		$\lambda_B: \lambda_6 = 6.734 \times 10^{-6}$ $\lambda_{8A} = 1.914 \times 10^{-6}$ $\lambda_{8B} = 6.734 \times 10^{-6}$ $\lambda_9 = 0.686 \times 10^{-6}$ $\lambda_{7A} = 2.613 \times 10^{-6}$ $\lambda_{7B} = 0.427 \times 10^{-6}$ $\lambda_{7C} = 1.453 \times 10^{-6}$ $\lambda_{7F} = 12.832 \times 10^{-6}$ $\lambda_{7G} = 1.302 \times 10^{-6}$ $\lambda_{7H} = 1.176 \times 10^{-6}$ $\lambda_{1N} = 0.280 \times 10^{-6}$ $\lambda_{1R} = 0.960 \times 10^{-6}$ $\lambda_{10B} = 0.134 \times 10^{-6}$ $\lambda_B = 37.245 \times 10^{-6}$	
A hidden failure in the equipment which essentially inhibits the transfer capability of the transmitting units and then a failure in the main transmitting unit.	$P_{AC} = \frac{\lambda_C}{\lambda_A + \lambda_C} (P_A \cdot P_C)$ P_A = previously identified P_C = the probability of the loss of the transfer to standby capability. $P_A = 5.202 \times 10^{-8}$ $P_C = (\lambda_C \cdot 2\ wk)$ $= (\lambda_C \cdot 336\ HR)$ $= 1.251 \times 10^{-3}$ $P_{AC} = 5.884 \times 10^{-12}$	$\lambda_A = 37.455 \times 10^{-6}$ $\lambda_C: \lambda_{1Q} = 0.844 \times 10^{-6}$ $\lambda_{1T} = 2.658 \times 10^{-6}$ $\lambda_{10A} = 0.221 \times 10^{-6}$ $\lambda_C = 3.723 \times 10^{-6}$	The factor $\left(\frac{\lambda_C}{\lambda_A + \lambda_C}\right)$ is the conditional probability that the hidden failure modes (λ_C) will occur prior to a main transmitting unit failure that initiates a transfer (λ_A). A two week preventive maintenance cycle is assumed to check the transfer capability of the glideslope station.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for $P_{STBY_{SEN}}$: (1) Loss of monitoring ability of the standby sensitivity monitor. (2) Failure causing the generation of a faulty path angle course width (DDM) parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{SEN}} = \frac{\lambda_{47B}}{\lambda_{47B} + \lambda_{ABCD}} \cdot P_{47B}$ $\times \frac{\lambda_{B_{SEN}}}{\lambda_A + \lambda_{B_{SEN}}} \cdot P_{B_{SEN}}$ $\times P_A$ P_{47B} Probability of sequence (1) $P_{B_{SEN}}$ Probability of sequence (2) $P_A = 5.202 \times 10^{-8}$ $P_{47B} = \lambda_{47B} \cdot 336$ HR $P_{B_{SEN}} = \lambda_{B_{SEN}} \cdot 336$ HR $P_{STBY_{SEN}} = 1.448 \times 10^{-15}$	$\lambda_{47B} = 2.892 \times 10^{-6}$ $\lambda_{ABCD} = 118.604 \times 10^{-6}$ (previously identified) $\lambda_{B_{SEN}}$: $\lambda_{7B} = 0.427 \times 10^{-6}$ $\lambda_{7F} = 12.832 \times 10^{-6}$ $\lambda_{7G} = 1.302 \times 10^{-6}$ $\lambda_{B_{SEN}} = 14.561 \times 10^{-6}$ $\lambda_A = 37.455 \times 10^{-6}$	Factors $\frac{\lambda_{47B}}{\lambda_{47B} + \lambda_{ABCD}}$ and $\frac{\lambda_{B_{SEN}}}{\lambda_A + \lambda_{B_{SEN}}}$ are conditional probabilities that compensate for sequence ordering of P_{47B} and $P_{B_{SEN}}$ respectively. Note that worst case failure rate for $\lambda_{B_{SEN}}$ has been used. Some of the failure rate of $\lambda_{D_{SEN}}$ may also produce a Cat. III course monitor alarm, thus leading to a worst case $P_{STBY_{SEN}}$ probability calculation.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
A failure in the standby monitoring system initiating a shutdown of the standby transmitting unit and then a failure in the main transmitting unit.	$P_{AD} = \frac{\lambda_D}{\lambda_A + \lambda_D} (P_A \cdot P_D)$ P_A = Previously identified. P_D = The probability of the loss of the standby transmitting unit due to a failure in the standby monitoring. $P_A = 5.202 \times 10^{-8}$ $P_D = (\lambda_D \cdot 5\ SEC)$ $= 5.581 \times 10^{-8}$ $P_{AD} = 1.503 \times 10^{-15}$	$\lambda_A = 37.455 \times 10^{-6}$ λ_D: $\lambda_{11} = 1.164 \times 10^{-6}$ $\lambda_{10C} = 0.572 \times 10^{-6}$ $\lambda_{46A} = 12.689 \times 10^{-6}$ $\lambda_{47A} = 9.367 \times 10^{-6}$ $\lambda_{48A} = 13.044 \times 10^{-6}$ $\lambda_{31} = 1.115 \times 10^{-6}$ $\lambda_{32} = 1.115 \times 10^{-6}$ $\lambda_{33} = 1.115 \times 10^{-6}$ $\lambda_D = 40.181 \times 10^{-6}$	The factor $\left(\frac{\lambda_D}{\lambda_A + \lambda_D}\right)$ is the conditional probability that a failure of λ_D will occur prior to a failure of λ_A. Note that after a failure in the main transmitting unit has occurred (a transfer accomplished), standby monitoring is meaningless.
Failure sequence leading to a shutdown for $P_{STBY\ CSE}$: (1) Loss of monitoring ability of the standby course monitor. (2) Failure causing the generation of a faulty course DDM, SDM, or RF parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY\ CSE} = \left(\frac{\lambda_{46B}}{\lambda_{46B} + \lambda_{ABCD}}\right) \cdot P_{46B} \times \left(\frac{\lambda_{B_{CSE}}}{\lambda_A + \lambda_{B_{CSE}}}\right) \cdot P_{B_{CSE}} \times P_A$ P_{46B} = Probability of sequence (1) $P_{B_{CSE}}$ = Probability of sequence (2) P_A = Probability of sequence (3), previously identified. $P_{46B} = (\lambda_{46B} \cdot 336\ HR)$ $P_{B_{CSE}} = (\lambda_{B_{CSE}} \cdot 336\ HR)$ $P_A = 5.202 \times 10^{-8}$ $P_{STBY\ CSE}$ = 9.6[illegible]5 × 10^{-15}	$\lambda_{46B} = 4.836 \times 10^{-6}$ λ_{ABCD}: $\lambda_A = 37.455 \times 10^{-6}$ $\lambda_B = 37.245 \times 10^{-6}$ $\lambda_C = 3.723 \times 10^{-6}$ $\lambda_D = 40.181 \times 10^{-6}$ $\lambda_{ABCD} = 118.604 \times 10^{-6}$ $\lambda_{B_{CSE}}$: $\lambda_6 = 6.734 \times 10^{-6}$ $\lambda_9 = 0.686 \times 10^{-6}$ $\lambda_{7B} = 0.427 \times 10^{-6}$ $\lambda_{7F} = 12.832 \times 10^{-6}$ $\lambda_{7G} = 1.302 \times 10^{-6}$ $\lambda_{B_{CSE}} = 21.981 \times 10^{-6}$	Factors $\left(\frac{\lambda_{46B}}{\lambda_{46B} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_{B_{CSE}}}{\lambda_A + \lambda_{B_{CSE}}}\right)$ are conditional probabilities that compensate for sequence ordering of P_{46B} and $P_{B_{CSE}}$ respectively. Note that worst case failure rate for $\lambda_{B_{CSE}}$ has been used since some of the failure rate of $\lambda_{B_{CSE}}$ may also produce a sensitivity (path angle width) Cat. III DDM alarm. Also no discrimination has been made as to which course parameter (DDM, SDM, or RF) is faulty. Hence, the entire probability calculation is worst case.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
lure sequence leading to a down for $P_{STBY_{CL}}$. (1) Loss of monitoring ability of the standby clearance monitor. (2) Failure causing the generation of a faulty clearance DDM, SDM, or RF parameter from the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY_{CL}} \frac{\lambda_{48B}}{\lambda_{48B}+\lambda_{ABCD}} \cdot P_{48B} \times \frac{\lambda_{B_{CL}}}{\lambda_A+\lambda_{B_{CL}}} \cdot P_{B_{CL}} \times P_A$ P_{48B} - Probability of sequence (1). $P_{B_{CL}}$ - Probability of sequence (2). $P_A = 5.202 \times 10^{-8}$ $P_{48B} = \lambda_{48B} \cdot 336$ HR $P_{B_{CL}} = \lambda_{B_{CL}} \cdot 336$ HR $P_{STBY_{CL}} = 2.282 \times 10^{-15}$	$\lambda_{48B} = 4.848 \times 10^{-6}$ $\lambda_{ABCD} = 118.604 \times 10^{-6}$ $\lambda_A = 37.455 \times 10^{-6}$ $\lambda_{B_{CL}}$: $\lambda_{8A} = 1.914 \times 10^{-6}$ $\lambda_{8B} = 6.734 \times 10^{-6}$ $\lambda_{7H} = 1.176 \times 10^{-6}$ $\lambda_{B_{CL}} = 9.824 \times 10^{-6}$	Factors $\frac{\lambda_{48B}}{\lambda_{48B}+\lambda_{ABCD}}$ and $\frac{\lambda_{B_{CL}}}{\lambda_A+\lambda_{B_{CL}}}$ are conditional probabilities that compensate for sequence ordering of P_{48B} and $P_{B_{CL}}$ respectively. A worst case probability calculation is made since the failure rate λ_{48B} is nondiscriminatory as to which clearance parameter (DDM, SDM, or RF) is faulty.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Failure sequence leading to a shutdown for P_{STBY}: (1) Loss of <u>all</u> standby monitoring ability. (2) Failure causing the generation of any faulty parameter of the standby transmitting unit. (3) Any failure in the main transmitting unit which can initiate a transfer.	$P_{STBY} = \frac{\lambda_{1H} + \lambda_{1SI}}{\lambda_{1H} + \lambda_{1SI} + \lambda_{ABCD}}$ $\times\ P_{1H} + P_{1SI}$ $\times \frac{\lambda_B}{\lambda_A + \lambda_B}$ $\cdot \left(\lambda_B \cdot 336\ HR\right)$ $\times P_A$ $(P_{1H} + P_{1SI}) =$ Probability of sequence (1). $(\lambda_B \cdot 336\ HR) =$ Probability of sequence (2). $P_{1H} = (\lambda_{1H} \cdot 336)$ $P_{1SI} = (\lambda_{1SI} \cdot 336)$ $P_A = 5.202 \times 10^{-8}$ $P_{STBY} = 2.314 \times 10^{-15}$	$\lambda_{1H} = 1.399 \times 10^{-6}$ $\lambda_{1SI} = 0.198 \times 10^{-6}$ $\lambda_{ABCD} = 118.604 \times 10^{-6}$ $\lambda_A = 37.455 \times 10^{-6}$ $\lambda_B = 37.245 \times 10^{-6}$	Factors $\left(\frac{\lambda_{1H} + \lambda_{1SI}}{\lambda_{1H} + \lambda_{1SI} + \lambda_{ABCD}}\right)$ and $\left(\frac{\lambda_B}{\lambda_A + \lambda_B}\right)$ are conditional probabilities that compensate for sequence ordering of $(P_{1H} + P_{1SI})$ and $(\lambda_B \cdot 336)$ respectively. Note that the probability $(\lambda_B \cdot 336)$ must be used rather than P_B because a two week period of failure (preventive maintenance cycle) must be used rather than the 5 second critical landing phase period for the glideslope.
Converters failures leading to a shutdown.	$P_{CONV} = (\lambda_{15} \times 3HR) \cdot (\lambda_{16} \times 5\ SEC)$ $P_{CONV} =$ Probability of both main converters failing. $P_{CONV} = 1.814 \times 10^{-13}$	$\lambda_{15} = \lambda_{16} = 6.598 \times 10^{-6}$	Note that since a power/environmental alarm will be produced if one of the converters fails, a downgrade from Cat. III performance will occur within 3 hours; hence, a 3 hour time interval is used.

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Two of the three course monitors/peak detectors failing, producing an alarm.	$P_{CSE} = \left(\lambda_{CSE} \cdot 336\ HRS\right)$ $\times \left(2 \cdot \lambda_{CSE} \cdot 5\ SEC\right)$ $= 1.815 \times 10^{-10}$	$\lambda_{CSE} = \lambda_{CSE1} = \lambda_{CSE2} = \lambda_{CSE3}$ λ_{CSE1}: $\lambda_{34A} = 12.689 \times 10^{-6}$ $\lambda_{19} = 1.115 \times 10^{-6}$ $1/3\ \lambda_{1C1} = 0.140 \times 10^{-6}$ $\lambda_{CSE1} = 13.944 \times 10^{-6}$ $\lambda_{CSE2} = \lambda_{35A} + \lambda_{20} + 1/3\lambda_{1C1}$ $= 13.944 \times 10^{-6}$ $\lambda_{CSE3} = \lambda_{36A} + \lambda_{21} + 1/3\lambda_{1C1}$ $= 13.944 \times 10^{-6}$	No discrimination is made among the course RF, SDM, and DDM alarms; hence, a worst case analysis results. Note that if each monitor were considered separately, the probability of failure of each of the 3 monitors is 1/5 of P_{CSE}. Note that it is assumed maintenance action will be employed within 2 weeks (336 HR) after a monitor abnormal due to a monitor mismatch occurs.
Two of the sensitivity monitors/peak detectors failing, producing an alarm.	$P_{SEN} = \left(\lambda_{SEN} \cdot 336\ HR\right)$ $\times \left(2 \cdot \lambda_{SEN} \cdot 5\ SEC\right)$ $= 1.035 \times 10^{-10}$	$\lambda_{SEN} = \lambda_{SEN1} = \lambda_{SEN2} = \lambda_{SEN3}$ λ_{SEN1}: $\lambda_{37A} = 9.367 \times 10^{-6}$ $\lambda_{22} = 1.115 \times 10^{-6}$ $1/3\lambda_{1C2} = 0.047 \times 10^{-6}$ $\lambda_{SEN1} = 10.529 \times 10^{-6}$ $\lambda_{SEN2} = \lambda_{38A} + \lambda_{23} + 1/3\lambda_{1C2}$ $= 10.529 \times 10^{-6}$ $\lambda_{SEN3} = \lambda_{39A} + \lambda_{24} + 1/3\lambda_{1C2}$ $= 10.529 \times 10^{-6}$	

Table F-2. Glideslope Shutdown Probabilities (Cont'd)

Probability Description	Probability Calculation	Failure Rate Data	Remarks
Two of the clearance monitors/ peak detectors failing, producing an alarm.	$P_{CL} = (\lambda_{CL} \cdot 336\ HR)$ $\times (2 \cdot \lambda_{CL} \cdot 5\ SEC)$ $= 1.908 \times 10^{-10}$	$\lambda_{CL} = \lambda_{CL1} = \lambda_{CL2} = \lambda_{CL3}$ λ_{CL1}: $\lambda_{40A} = 13.044 \times 10^{-6}$ $\lambda_{25} = 1.115 \times 10^{-6}$ $1/3\lambda_{1C4} = 0.140 \times 10^{-6}$ $\lambda_{CL1} = 14.299 \times 10^{-6}$ $\lambda_{CL2} = \lambda_{41A} + \lambda_{26} + 1/3\lambda_{1C4}$ $= 14.299 \times 10^{-6}$ $\lambda_{CL3} = \lambda_{42A} + \lambda_{27} + 1/3\lambda_{1C4}$ $= 14.299 \times 10^{-6}$	Worst case analysis is again considered since no discrimination has been made among the clearance DDM, SDM, or RF alarms.
Two of the near field monitors/ peak detectors failing, producing an alarm.	$P_{NF} = (\lambda_{NF} \cdot 336\ HR)$ $\times (2 \cdot \lambda_{NF} \cdot 5\ SEC)$ $= 1.403 \times 10^{-10}$	$\lambda_{NF} = \lambda_{NF1} = \lambda_{NF2} = \lambda_{NF3}$ λ_{NF1}: $\lambda_{43A} = 11.099 \times 10^{-6}$ $\lambda_{28} = 1.115 \times 10^{-6}$ $1/3\lambda_{1C3} = 0.047 \times 10^{-6}$ $\lambda_{NF1} = 12.261 \times 10^{-6}$ $\lambda_{NF2} = \lambda_{44A} + \lambda_{29} + 1/3\lambda_{1C3}$ $= 12.261 \times 10^{-6}$ $\lambda_{NF3} = \lambda_{45A} + \lambda_{30} + 1/3\lambda_{1C3}$ $= 12.261 \times 10^{-6}$	Note that the failure of both the DDM and SDM has been included in the near field monitor channel failure rate, since the SDM strap option for a general alarm will be utilized.
Failure inhibiting the monitors while the ILS signal is radiated. A shutdown status will result - loss of Cat. III and Cat. II status.	$P_{INHIB} = (\lambda_{1S2} + \lambda_{1W} \cdot 5\ SEC)$ $= 3.411 \times 10^{-9}$	$\lambda_{1S2} = 2.316 \times 10^{-6}$ $\lambda_{1W} = 0.140 \times 10^{-6}$	

Appendix G

Localizer Preventive Maintenance Checks

Appendix G

Localizer Preventive Maintenance Checks

This appendix consisting of table G-1, details the preventive maintenance checks necessary to detect hidden failures in the localizer.

Table G-1. Localizer Preventive Maintenance Checks

Identification: Item	Identification: No.	Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Course Monitor Channels (MAIN)	35 36 37	Loss of monitoring ability, producing no alarms.	(1) Flip switch on each monitor to check DDM alarm. (2) Misalign SDM phase shifter and check SDM alarms; then using front panel meter, realign SDM phase shifter. (3) Lower course transmitter power, and check RF alarms; then using front panel meter, readjust RF power level. *Note: Control unit logic for transfer capability may be simultaneously checked if "local" or "remote" mode of operation is selected.	Weekly	3.0 min.
Sensitivity Monitor Channels (MAIN)	38 39 40	Same as above.	(1) Flip switch on each monitor to check DDM alarm.*	Weekly	0.5 min.
Clearance Monitor Channels (MAIN)	43 44 45	Same as above.	(1) Flip switch on each monitor to check DDM alarm.* (2) Disconnect output of clearance transmitter to check RF and SDM alarms.*	Weekly	1.0 min.
Near Field Monitor Channels	41 42	Same as above. (Not hazardous)	(1) Flip switch on each monitor to check DDM alarm. Note: Control unit logic for shut-down can be checked simultaneously.	Monthly	0.5 min.
Standby Course Monitor Channel	[illegible]	Loss of monitoring ability, producing no alarm.	Same as main course monitors except misalignment of standby transmitter: (1), (2), (3) **Note: Control unit logic for stand-by alarm processing may be simultaneously checked if "local" or "remote" mode of operation is selected.	2 weeks	2.0 min.

Table G-1. Localizer Preventive Maintenance Checks (Cont'd)

Identification		Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Item	No.				
Standby Sensitivity Monitor Channel	47	Loss of monitoring ability, producing no alarm.	(1) Flip switch on monitor to check DDM alarm.**	2 weeks	0.2 min.
Standby Clearance Monitor Channel	48	Same as above.	(1) Flip switch on monitor to check DDM alarm.** (2) Disconnect output of clearance transmitter to check RF and SDM alarms.**	2 weeks	0.6 min.
Identification Monitor Ass'y	34	Loss of one of the main I.D. monitors, producing no alarms. (Not hazardous)	(1) Flip switch on main I.D. unit to "CONTINUOUS" to check if alarms occur on all I.D. monitors.	Monthly	0.5 min.
		Loss of standby I.D. monitor, producing no alarm.	(2) Flip switch on standby I.D. unit to "CONTINUOUS" to check if alarm occurs. Note: I.D. monitor ass'y logic and I.D. control unit processing may be checked simultaneously.	2 weeks	0.5 min.
Control Unit	01	Inability to process a transfer signal from the integral course, sensitivity, I.D., and/or clearance monitors.	By checking the individual monitor channel alarms this hidden failure mode can also be checked. Note that the "local" or "remote" mode of operation is required for control unit processing logic checks.	Weekly	—
		Inability to process a shutdown signal initiated by the NF, FF, and/or Cat. II course DDM. (Not hazardous)	Same as above: (indication - "SHUT-DOWN" on control unit front panel).	Monthly	—
		Inability to process a mismatch condition of any or all monitor sets. (Not hazardous)	Same as above: (indication - "MIS-MATCH" on control unit front panel).	Monthly	—
		Inability to process a standby alarm.	Same as above: (indication - "AB-NORMAL" only on control unit front panel).	2 weeks	—

Table G-1. Localizer Preventive Maintenance Checks (Cont'd)

Identification: Item	Identification: No.	Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Control Unit (continued)	01	Inability to process any or all power/environmental alarms. (Not hazardous)	(1) Flip each voltage circuit breaker switch on each converter and check if "CONVERTER FAIL" light lights. (2) Flip "DC LOAD" and "AC INPUT" circuit breakers and check if "CHARGER FAIL" and "AC FAIL" lights respectively light.	6 months	5.0 min.
		Inability to shutdown either the main or standby transmitting unit. (Not hazardous)	By checking the individual monitor channel alarms this hidden failure mode can also be checked. Note that the local or remote mode of operation is required for control unit processing logic checks.	Monthly	—
		Inability to effect a change of units feeding the antennas.	Same as above (indication - TRANSFER' on control unit front panel).	2 weeks	—
		Inability to process a main inhibit to the monitor channels.	Same as above (note that when two integral monitor alarms exist, a transfer will occur. If an immediate shutdown does not follow (within 2 seconds) the main inhibit is functioning properly. (If the alarms are left on longer than 2 seconds - monitor channel simulated alarm with switch - a shutdown will occur.)	2 weeks	—
		Inability to process a standby inhibit to the standby inhibit to the standby monitor channels. (Not hazardous)	Same as above (note that if a standby DDM alarm is generated from a standby monitor channel, the standby transmitter should shut down and the standby monitor channels be inhibited. If the inhibit is not generated, all RF and SDM lights on all standby monitors will light).	Monthly	—
		Inability to generate a correct shutdown alert signal. (Not hazardous)	Same as above (note that when the two near field alarms are simulated, a shutdown after a time delay will result. Prior to that shutdown, the shutdown alert should be generated).	Monthly	—

Table G-1. Localizer Preventive Maintenance Checks (Cont'd)

Identification		Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Item	No.				
Changeover and Test	12	Inability to changeover transmitting units by switching circuitry.	When the SDM phase shifter is misaligned in checking the SDM monitoring circuitry of the course monitors, a transfer and not a shutdown should result to indicate failure mode has not occurred.	2 weeks	—
Battery Charger	15 16	Loss of the equalize voltage capability. (Not hazardous)	(1) Turn "EQUALIZE TIMER" dial and then check front panel meter to see if voltage is approximately 33 volts. (each charger) (2) Check respective batteries of each charger to see if full charge has been maintained (all cells).	6 months	15.0 min.
Far Field Monitor Channels	56 57 58	Loss of monitoring ability, producing a Cat. III DDM alarm. (Not hazardous) Loss of monitoring ability, producing no alarms.	(1) Flip switch on each monitor to check DDM alarm. Note: Both hidden failure modes are checked. Note: FFM combining logic may be simultaneously checked.	Weekly	3.0 min.
Combining Circuits	49	Inability to generate a Cat. III disable signal.	When two far field monitor alarms are activated (above), a Cat. III disable should occur at the remote control tower after a nominal 20 second delay. Signal check may be accomplished with a vom.	2 weeks	—
		Inability to process a Cat. II monitor alarm. (Not hazardous) Inability to process a shutdown alert. (Not hazardous)	When two far field monitor alarms are activated, both a shutdown alert and a Cat. II monitor alarm (shutdown) should occur after their respective time delays. Signal checks may be accomplished with a VOM.	2 weeks	—
		Inability to process a mismatch condition at the FFM. (Not hazardous)	When only one far field monitor alarm is activated, a mismatch signal should occur after a time delay (120 sec). Signal check may be accomplished with a VOM.	2 weeks	—

Table G-1. Localizer Preventive Maintenance Checks (Cont'd)

Identification: Item	No.	Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task time
Combining Circuits (continued)	4?	Inability to process a PWR TEMP alarm for either remote or local display. (Not hazardous)	Turn far field monitor charger circuit breaker off and observe CHARGER FAIL light light. Use VOM to check PWR TEMP FAIL signal to localizer station.	? months	1.0 min.
Battery Charger (Far Field)	50	Low voltage battery disconnect circuit failure, disconnecting the battery from the load.	Turn far field monitor charger circuit breaker off and see far field monitor maintains normal operation (no monitor alarms).	Monthly	0.5 min.
		Loss of equalize charge capability after a power outage. (Not hazardous) Continuous equalize voltage only. (Not hazardous)	(1) Check terminal voltage of FFM battery during normal operation. (2) Disconnect FFM charger with circuit breaker. (3) Reconnect FFM charger and observe a rise in FFM battery voltage (equalize voltage). Note: Above procedure checks both failure modes.	6 months	3.0 min.
FFM Battery		Inability to maintain full charge	Check all cells of battery.	Monthly	2.0 min.

Appendix H

Glideslope Preventive Maintenance Checks

Table H-1. Glideslope Preventive Maintenance Checks

Identification: Item	Identification: No.	Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Course Monitor Channels (MAIN)	34 35 36	Loss of monitoring ability, producing no alarms.	(1) Flip switch on each monitor to check DDM alarm. (2) Misalign SDM phase shifter and check SDM alarms; then using front panel meter, realign SDM phase shifter. (3) Lower course transmitter power, and check RF alarms; then using front panel meter, readjust RF power level. *Note: Control unit logic for transfer capability may be simultaneously checked if "local" or "remote" mode of operation is selected.	Weekly	3.0 min.
Sensitivity Monitor Channels (MAIN)	37 38 39	Same as above.	(1) Flip switch on each monitor to check DDM alarm.*	Weekly	0.5 min.
Clearance Monitor Channels (MAIN)	40 41 42	Same as above.	(1) Flip switch on each monitor to check DDM alarm.* (2) Disconnect output of clearance transmitter to check RF and SDM alarms.*	Weekly	1.0 min.
Near Field Monitor Channels	43 44 45	Same as above.	(1) Flip switch on each monitor to check DDM alarm.*	Monthly	0.5 min.
Standby Course Monitor Channel	46	Loss of monitoring ability, producing no alarm.	Same as main course monitors except misalignment of standby transmitter: (1), (2), (3) **Note Control unit logic for standby alarm processing may be simultaneously checked if "local" or "remote" mode of operation is selected.	2 weeks	2.0 min.
Standby Sensitivity Monitor Channel	47	Same as above.	(1) Flip switch on monitor to check DDM alarm.**	2 weeks	0.2 min.

Table H-1. Glideslope Preventive Maintenance Checks

Identification: Item	No.	Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Standby Clearance Monitor Channel	48	Loss of monitoring ability, producing no alarm.	(1) Flip switch on monitor to check DDM alarm.** (2) Disconnect output of clearance transmitter to check PF and SDM alarms.**	2 weeks	0.6 min.
Misalignment Detector	49	Loss of alignment detection, producing no alarm.	Flip switch on control unit front panel (MISALIGNMENT DETECTOR TEST switch) to "test" and wait for glideslope shutdown. Note control unit logic is simultaneously checked.	Weekly	0.2 min. (time delay of 2.25 minutes not included)
Control Unit	01	Inability to process a transfer signal from the integral course, sensitivity, and/or clearance monitors.	By checking the individual monitor channel alarms this hidden failure mode can also be checked. Note that the "local" or "remote" mode of operation is required for control unit processing logic checks.	Weekly	——
		Inability to process a shutdown signal initiated by the misalignment detector. Inability to process a mismatch condition of any or all monitor sets. (Not hazardous)	Checked by testing the misalignment detector alarm when in "local" or "remote" mode of operation. Checked when tes[illegible] monitor channel alarms: (indication - "MISMATCH" on control unit front panel).	Weekly	——
		Inability to process a standby alarm.	Checked when testing monitor channel alarms: (indication - "ABNORMAL" only on control unit front panel).	2 weeks	——
		Inability to process any or all power/environmental alarms. (Not hazardous)	(1) Flip each voltage circuit breaker switch on each converter and check if "CONVERTER FAIL" light lights. (2) Flip "DC LOAD" and "AC INPUT" circuit breakers and check if "CHARGER FAIL" and "AC FAIL" lights respectively light.	6 months	5.0 min.
		Inability to shutdown either the main or standby transmitting unit. (Not hazardous)	By checking the individual monitor channel alarms this hidden failure mode can also be checked. Note that the "local" or "remote" mode of operation is required for control unit processing logic checks.	Monthly	——

Table H-1. Glideslope Preventive Maintenance Checks

Identification		Failure Mode	Preventive Maintenance Task Description	Recommended Task Frequency	Estimated Task Time
Item	No.				
Control Unit (continued)	9	Inability to effect a change of units feeding the antennas.	By checking the individual monitor channel alarms this hidden failure mode can also be checked. Note that the 'local' or "remote" mode of operation is required for control unit processing logic checks. (indication - 'transfer' on control unit front panel).	2 weeks	—
		Inability to process a main inhibit to the monitor channels.	Same as above: (note that when two integral monitor alarms exist, a transfer will occur. If an immediate shutdown does not follow (within 2 seconds) the main inhibit is functioning properly. (If the alarms are left on longer than 2 seconds - monitor channel simulated alarm with switch - a shutdown will occur).	2 weeks	—
		Inability to process a standby inhibit to the standby monitor channels. (Not hazardous)	Same as above: (note that if a standby DDM alarm is generated from a standby monitor channel, the standby transmitter should shutdown and the standby monitor channels be inhibited. If the inhibit is not generated, all RF and SDM lights on all standby monitors will light).	Monthly	—
Changeover and Test	10	Inability to changeover transmitting units by switching circuitry.	When the SDM phase shifter is misaligned in checking the SDM monitoring circuitry of the course monitors, a transfer and <u>not</u> a shutdown should result to indicate failure mode has not occured.	2 weeks	—
Battery Charger	13 14	Loss of the equalize voltage capability. (Not hazardous)	(1) Turn "EQUALIZE TIMER" dial and then check front panel meter to see if voltage is approximately 33 volts. (each charger) (2) Check respective batteries of each charger to see if full charge has been maintained (all cells).	6 months	15.0 min.

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